

# Clarkson Airshed Study

## A Scientific Approach to Improving Air Quality

### Part II – The Ambient Air Monitoring Program



**November 2006**

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# Acknowledgements

*This report has been prepared with contribution from the Ontario Ministry of the Environment's Central Region, Technical Support Section, and Halton-Peel District Office, and from the Environmental Monitoring and Reporting Branch. Environment Canada, National Air Pollution Surveillance program is also acknowledged for providing air toxics data and analysis to this study.*

*Published November 2006  
© Queen's Printer for Ontario  
Printed in Ontario, Canada  
PIBS: 6031*

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# Executive Summary

## Clarkson Airshed Study: Part II - The Ambient Air Monitoring Program

In 2000, the Ministry of the Environment (Ministry) initiated the Clarkson Airshed Study (CAS) in order to address concerns by the Ministry of Environment (Ministry), the public and other stakeholders about air quality, specifically levels of suspended fine particulate matter, in the Clarkson area. The overall study consists of the following four parts:

- (i) identifying major sources of specific target pollutants;
- (ii) conducting an ambient air monitoring program in and around the airshed to determine whether or not air quality in the area is “taxed” or is at risk;
- (iii) determining contributions and impacts from the major sources of the emissions, through air dispersion modeling; and
- (iv) looking at abatement options that may take area industries “beyond compliance” as a means of improving airshed quality.

This report presents the findings of Part (II) of the study which was initiated in 2001, when the ministry began plans to conduct an 18-month ambient air monitoring program in the Clarkson Airshed area.

The scope of work involved the installation of five new ambient air monitoring stations to augment data collected from one existing monitoring station.

The stations were located strategically within a study area that included the Clarkson Airshed [see **Figure 3-2** in Section - Three of this report]. The target pollutants monitored at these stations were: (i) total suspended particulates (TSP); (ii) inhalable particulate matter (PM<sub>10</sub>); (iii) respirable particulate matter (PM<sub>2.5</sub>); (iv) nitrogen oxides (NO<sub>x</sub>); (v) nitric oxide (NO); (vi) nitrogen dioxide (NO<sub>2</sub>); and (vii) volatile organic compounds (VOCs).

The actual length of the program monitoring period was extended from the originally scheduled 18 months to a period of 22 months in order to collect additional ambient air quality data over a second winter period.

Data from the monitoring program indicated that:

- Annual average 98<sup>th</sup> percentile 24 hour concentrations of PM<sub>2.5</sub> measured during the CAS ambient air monitoring program at four of the six CAS stations, exceeded the PM<sub>2.5</sub> *project benchmark concentration* of 30 µg/m<sup>3</sup> both for 2004 and for the whole study period (2003-2005).

This *benchmark concentration* was based on the proposed Canada Wide Standard (CWS) for PM<sub>2.5</sub> of 30 µg/m<sup>3</sup> and is used in this program as part of the Ministry’s analysis of CAS study area PM<sub>2.5</sub> concentrations.

These elevated levels were found to be

particularly evident during smog events and were due largely to vehicular emissions, long range transport and industrial source emissions. The elevated concentrations occurred when the wind direction was predominantly from the south and south southwest.

- Local industries were found to contribute as much as 25 percent of the  $PM_{2.5}$  concentrations in the airshed area.
- Although  $PM_{10}$  annual average concentrations were consistent from station to station across the CAS, they did exceed the 24 hour Ministry interim Ambient Air Quality Criteria (AAQC) value of  $50 \mu g/m^3$  on a number of occasions. These elevated  $PM_{10}$  concentrations were also most evident during south to southwest wind conditions and were tied to smog events, long range transport and industrial source emissions.

In summary, these results confirm that, at times, especially during smog events, the CAS study area represents a “taxed” or compromised area with respect to respirable particulate matter ( $PM_{2.5}$ ).

Additional findings of the ambient air monitoring program were:

- Vehicular emissions were found to be a significant source of Nitric Oxide (NO) and fine particulate matter ( $PM_{2.5}$ ).
- Nitric oxide (NO) concentrations recorded adjacent to the Queen Elizabeth Way (QEW) during the morning rush hour were found to be 36 % higher than during the afternoon rush hour. Through modeling of these emissions, however, NO concentrations were predicted to decrease by 80% at 300 metres from the roadway [Note: There is no Ministry AAQC for this parameter].

- The concentration of dichloromethane exceeded the Ministry’s 24-hour AAQC and Reg 419 Schedule 3 standard of  $220 \mu g/m^3$  on one day at one station. All other samples were considerably below the appropriate criterion or standards for VOCs.
- VOC concentrations in the Clarkson airshed study area were found to be similar to major industrial areas such as Toronto and Hamilton. Based on a limited data set, two VOCs of interest, acrolein and acrylonitrile, require further monitoring and assessment. The levels found for these two compounds exceeded the standards identified in Reg. 419 Schedule 3; however, further work is needed to confirm these measurements.

The Ministry will carry out additional monitoring for both acrolein and acrylonitrile and will continue with Part III of the CAS study to evaluate the contribution of specific sources to the air quality in the air shed.

Part III will extend our assessment of long range transport or transboundary impacts of key pollutants such as  $PM_{2.5}$  on the CAS study area. Such an assessment will allow for a more specific identification of pollutant concentrations within the study area that are directly attributable to the transboundary issue.

Following this, the Ministry will proceed with Part IV of the CAS that will focus on achieving further abatement of the target pollutants from the 57 identified emitters that operate in the area.

It is expected that in 2007/2008, Part IV of the study will be initiated, which will include the establishment of an Advisory Committee consisting of representatives from the local public health department, municipalities, elected officials rate payers associations, and Ministry representatives to liaise with industry and stakeholders with respect to the development and implementation of a permanent ambient air monitoring program for the community.

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## Section - One

# Glossary of Terms

## Clarkson Airshed Study: Part II - The Ambient Air Monitoring Program

**Acidic deposition:** refers to the deposition of a variety of acidic pollutants (acids or acid-forming substances such as sulphates and nitrates) on biota, land or in waters of the Earth's surface

**Air Quality Index (AQI) station:** continuous monitoring station operated by the Ministry and used to inform the public of general ambient air quality levels over an entire region (not a localized area) on a real-time basis; station reports on criteria pollutant levels that are not unduly influenced by a single emission source, but rather are the result of emissions from multiple sources, including those in neighbouring provinces and states

**Airshed:** a geographical region covered by a volume of air that has similar characteristics

**Air toxics:** airborne pollutants that can cause health effects such as cancer, genetic mutations, organ damage, changes to the nervous system, or even physiological harm as a result of prolonged exposure, even to relatively small amounts

**Ambient air:** outdoor or open air

**Ambient Air Quality Criterion (AAQC):** maximum concentration or level (based on

potential effects) of a contaminant that is desirable or considered acceptable in the ambient air; specific contaminant concentrations are designated by the MOE under O.Reg 419/05.

**Aromatic hydrocarbon:** a compound where the double-bond carbon atoms occur in a ring-type pattern

**CAS:** Clarkson Airshed Study

**Carcinogen:** an agent that incites carcinoma (cancer) or other malignancies in humans

**Continuous pollutant:** contaminant for which a continuous record exists; effectively, pollutants that have hourly data

**Continuous station:** a monitoring station at which pollutants are measured on a real-time basis and data is generated hourly (for example ozone, sulphur dioxide, PM<sub>2.5</sub>)

**Detection limit:** minimum concentration of a contaminant that can be determined by means of laboratory analysis of an ambient air sample filter or by a continuous real time monitoring instrument

**Exceedance:** violation of the air pollutant concentration levels defined under Ministry legislation or legislation set by other agencies such as CCME (Canadian Council of the Ministers of Environment)

**Fine particulate matter (PM<sub>2.5</sub>):** see “respirable particulate matter”

**Fossil fuels:** natural gas, petroleum, coal and any form of solid, liquid or gaseous fuel derived from such materials for the purpose of generating heat

**Inhalable particulate matter (PM<sub>10</sub>):** represent up to 60 per cent of the total suspended particulate matter; composed of both coarse particles (diameter 2.6 to 10.0 microns) and fine particles (diameter < 2.5 microns)

**Micrometre or micron:** a millionth of a metre

**Nitrogen Dioxide (NO<sub>2</sub>):** a reddish-brown gas with a pungent and irritating odour

**Nitric Oxide (NO):** a precursor of ozone, NO<sub>2</sub> and nitrate; nitric oxide is usually emitted from combustion processes; is converted to nitrogen dioxide (NO<sub>2</sub>) in the atmosphere and then becomes involved in the photochemical processes and /or particulate formation

**Nitrogen Oxides (NO<sub>x</sub>):** generally considered to be the sum of NO and NO<sub>2</sub>

**Ozone episode:** a period during which elevated ozone levels (greater than 80 ppb maximum hourly concentration) exist over a widespread area (hundreds of kilometers)

**Particulate matter:** refers to all airborne finely divided solid or liquid material with an aerodynamic diameter smaller than 44 microns

**Percentile value:** percentage of the data set that lies below the stated value; ie. if the 98 percentile value is 0.10 ppm, then 98 per cent of the data are equal to or below 0.10 ppm

**Photochemical oxidant:** a complex mixture of chemicals produced in the atmosphere; these air pollutants are formed by the action of sunlight on oxides of nitrogen and VOCs

**Photochemical reaction:** chemical reaction influenced or initiated by light, particularly ultraviolet light

**Precursor pollutant:** usually a primary pollutant which can be transformed (or enable the transformation) into secondary pollutants

**Primary pollutant:** contaminant emitted directly to the atmosphere

**Respirable particulate matter (PM<sub>2.5</sub>):** particles smaller than about 2.5 microns in aerodynamic diameter, which arise mainly from condensation of hot vapours and chemically-driven gas-to-particle conversion processes; these particles are fine enough to penetrate deep into the lungs and have the greatest negative impact on human health (see also “fine particulate matter”)

**Secondary pollutant:** contaminant formed from other pollutants in the atmosphere by means of a chemical reaction or reactions

**Size selective inlet (SSI):** used in conjunction with a high volume particulate sampler to separate particle size, such as; respirable particulate matter (PM<sub>2.5</sub>) and inhalable particulate matter (PM<sub>10</sub>)

**Smog:** a contraction of smoke and fog; colloquial term used for photochemical pollution, which includes ozone and other contaminants; generally noticeable as a brownish haze

**Smog advisory:** an advisory which is issued by the Ministry to the public when there is a strong likelihood of a smog episode

**Taxed airshed area:** a geographical region covered by a volume of air that has similar characteristics and in which air quality is comprised of elevated levels of air contaminants

**Torr:** is a symbol for the word “torr” otherwise known as millimeter of mercury (mmHg); it is a non-SI unit of pressure which represents the pressure that supports a column of mercury 1 millimetre high; the unit is named after Evangelista Torricelli, Italian physicist and mathematician, for his discovery of the principle of the barometer in 1643.

**Toxic deposition:** deposition of an airborne toxic pollutant at ground, vegetative or surface levels

**Toxic pollutant:** substance that can cause cancer, genetic mutations, organ damage, changes to the nervous system, or even physiological harm as a result of prolonged exposure, even to relatively small amounts

**Troposphere:** atmospheric layer extending about 10 kilometers above the earth’s surface

## *Section - Two*

# Introduction / Background

## **Clarkson Airshed Study: Part II - The Ambient Air Quality Monitoring Program**

In 2001, the Ministry of the Environment (Ministry) took steps to design and undertake an ambient air monitoring program as part of the Clarkson Airshed Study (CAS).

This Study had been initiated by the Ministry in 2000 in response to the following concerns: (i) numerous complaints from the local community concerning poor air quality, (ii) elevated levels of inhalable particulate matter (PM<sub>10</sub>) being measured in community downwind of the Clarkson Airshed and, (iii) an evaluation of historical regional monitoring data showing potential sources of nitrogen oxide emissions within the area of the airshed.

Given the public complaints and monitoring information available at the time, the Ministry suspected that the Clarkson Airshed area was “taxed” with respect to air quality.

For all these reasons, the Ministry initiated a study to identify the major sources of targeted pollutants, the cumulative impacts of these pollutants on ambient air concentrations, and the

relative contribution of major sources to the air quality in the area of the airshed.

The study consists of the following parts:

**PART I** - Identify major sources of targeted pollutants.

**PART II** - Conduct an 18 month ambient air monitoring program.

**PART III** - Require major industrial sources of targeted pollutants to complete emission inventories, conduct air dispersion modeling and submit findings to the Ministry. Complete regional modeling to evaluate the contribution of these sources to the air quality in the area of the airshed.

**PART IV** - Implement abatement programs to reduce emissions of the targeted pollutants and develop and maintain an industry self-monitoring program in the airshed area.



In **PART I**, the Ministry identified the CAS study area to be an area as shown in **Figure 3.1** of Section - Three. It is an area that encompasses a larger area than what may be considered the actual Clarkson airshed and allows for assessment of the impact of vehicular, long range transport and industrial emissions which flow into and out of the airshed.

The pollutants that were identified to be of concern in the airshed were: (i) total suspended particulates (TSP); (ii) inhalable particulate matter (PM<sub>10</sub>); (iii) respirable particulate matter (PM<sub>2.5</sub>); (iv) nitrogen oxides (NO<sub>x</sub>); (v) nitric oxide (NO); (vi) nitrogen dioxide (NO<sub>2</sub>); and (vii) volatile organic compounds (VOCs).

Once the boundaries of the study area and the target pollutants were identified, the Ministry compiled a list of all potential sources emitting these pollutants. Given the Ministry's knowledge of land uses in the area and its familiarity with local topographic and meteorological conditions, the following source sectors were considered: (i) local industry; (ii) transportation, specifically major highways such as the QEW; (iii) residential communities (source of heating emissions); and (iv) long range transport of air pollutants into the airshed from sources external to the area.

On examining each sector, the Ministry identified 133 local industrial/commercial sources and several municipal roads that were considered to be potential emitters of the target pollutants. Of these 133 industrial / commercial sources, 57 were found to be emitters of the target pollutants.

The Ministry then conducted detailed inspections at the 57 industrial/commercial facilities to determine if they were in compliance with Ministry legislation and whether or not there was an opportunity for these facilities to reduce the emissions of target pollutants.

The Ministry asked these 57 facilities to quantify their emissions so that the Ministry could identify which of them may be in non-

compliance and/or considered to be "significant emitters". To this end, facilities identified as exceeding the threshold emission levels for target pollutants established by Ontario Regulation 127/01 were considered significant pollutant emission sources or "significant emitters".

Out of 57 industrial/commercial facilities evaluated, all were found to be operating under a current Ministry Environmental Protection Act (EPA) Section 9 Certificate of Approval (Air) and were in compliance with Ministry legislation. However, 22 of these facilities were found to be "significant emitters". These 22 include industrial facilities such as: (i) Universal Drum; (ii) Petro-Canada Lubricants Centre; (iii) St. Lawrence Cement; (iv) Orion Bus; (v) PPG Canada Inc., and (vi) Ashland Chemicals.

**PART II** of the CAS, to which this report is dedicated, involved designing and implementing an 18-month ambient air monitoring program.

The field monitoring, which actually lasted 22 months, was conducted between June 2003 and March 2005 and utilized six ambient air monitoring stations in the CAS study area. The monitoring program was designed to achieve three key objectives: (i) collection and analysis of samples which could be considered representative of the emissions from various sectors identified; (ii) determination of background concentrations of target pollutants; and (iii) estimation of the impact of each sector on the air quality in the study area.

The monitoring stations were located using meteorological data that the Ministry had compiled on wind speed and direction in the area and the proximity to the identified source sectors.

In July 2003, under **PART III**, the District Office advised all 22 facilities identified in Part I of the study that the Ministry considered them to be "significant emitters" of the target pollutants. In order to confirm the extent of TSP, PM<sub>10</sub>,

PM<sub>2.5</sub>, NO<sub>x</sub> (NO + NO<sub>2</sub>) and VOC emissions from these emitters, each facility was requested to complete a site-wide emission inventory and air dispersion modeling assessment of their operations. Data from these assessments will also be used to evaluate the contribution of these facilities to the air quality in the study area.

It is important to note that Part III will also extend our assessment of long range transport or transboundary impacts of key pollutants such as PM<sub>2.5</sub> on the CAS study area. Such an assessment will allow for a more specific identification of pollutant concentrations within the study area that are directly attributable to the transboundary issue.

It is expected that Part III of the CAS will be completed in the fall/winter of 2006.

**Part IV** of the study has not yet been started. It will involve asking all 57 industrial/commercial facilities identified as emitters of targeted pollutants to implement abatement programs to further reduce pollutant emissions.

To assist in achieving the objectives of this part of the CAS, the Ministry intends to approach 10 of the 22 “significant emitters” and interested area stakeholders in order to establish an Advisory Committee consisting of representatives from: (i) the local community; (ii) the local Health Department; (iii) municipalities; (iv) local politicians; and (v) the Ministry. The Advisory Committee will liaise with industry and stakeholders in the development and implementation of a permanent ambient air monitoring program for the Clarkson airshed and vicinity. It is expected that Part IV will be initiated in 2007/2008.

In order to achieve better air quality in the Clarkson area, existing sources that participate in the CAS are being asked to go beyond compliance. This approach, like that taken in cities such as Hamilton will be successful if it has the cooperation of industry, commercial operators and other levels of government.

As noted above, the remainder of the report presents the findings of Part II of the CAS study, the 22 month ambient air monitoring program.

## Section - Three

# Network Operations & Data Assessment

## Clarkson Airshed Study: Part II - The Ambient Air Monitoring Program

### 3.0 Description of the Monitoring Program

The ambient air-monitoring program began on June 1, 2003 and was completed on March 31, 2005.

**Figure 3-1** illustrates the CAS boundaries, which are identified as; the Queen Elizabeth Way to the north, Winston Churchill Blvd to the west, Southdown Road to the east and Lake Ontario to the south. The Clarkson Study Area, encompasses a larger area, and assesses the impact of vehicular and industrial emissions into the CAS.

The Ministry of the Environment's Central Region, Halton-Peel District Office and Technical Support Section as well as staff from EMRB work together to select six ambient air monitoring locations in order to capture representative emissions from all sectors such as: residential, transportation, industrial and trans-boundary.

The ambient air monitoring stations are shown in **Figure 3-2** of page 3-2. Five ambient air-monitoring stations were strategically located to augment data that was being already collected from one existing monitoring station located in the CAS STN 46117 (see below).

A station number and site description was assigned to each location. Only a shortened version of the site description is used throughout the report. The shortened version is shown in green below.

The ambient air monitoring station identification numbers and site descriptions are as follows:

- 1) STATION # 44075  
9<sup>th</sup> Line and North of QEW,  
Oakville,  
**Stn QEW West**
- 2) STATION #44080  
MTO Rd., South Sheridan Way  
and QEW, Oakville, STN  
**Stn QEW East**

**Figure 3-1 Clarkson Airshed Study Area****Figure 3-2 Location Of Air Monitoring Stations**

- 3) STATION #44086  
Deer Run, West of Winston  
Churchill Blvd., Oakville,  
*Stn 44086 Residential*
- 4) STATION #44083  
South of Ford Dr., West of Royal  
Windsor Dr.,  
Oakville  
*Stn Ford Dr*
- 5) STATION #46128  
Royal Windsor Dr. and Winston  
Churchill Blvd.  
Mississauga  
*Stn Industrial Centre*
- 6) STATION #46117  
Meadow Wood Park and East of  
Southdown,  
Mississauga (existing MOE STN)  
*Stn Industrial East*

One additional station "MET", containing meteorological equipment only, was installed at the Clarkson Sewage Treatment Plant on Lakeshore Road, Mississauga.

Data collected at three existing Ministry AQI stations (Burlington, Mississauga, and Oakville) were also used in the CAS ambient air monitoring program. These stations were used to provide background air quality information for the study area.

**Table 3-1** lists all the sampling stations and equipment used in the air monitoring program.

As stated in Section - Two of this report, the target pollutants monitored at the CAS stations include:

- 1) Total suspended particulates (TSP), inhalable particulate matter (PM<sub>10</sub>) and respirable particulate matter (PM<sub>2.5</sub>);
- 2) Nitrogen oxides (NO<sub>x</sub>), nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>);

- 3) Volatile organic compounds (VOCs).

A description of the way in which each of the above target pollutants affect air quality, and the methodologies used to collect and analyze the samples are explained in detail in Section - Four of this report.

### 3.1 Telemetry and Data Acquisition System

All six air-monitoring stations were networked to receive and send continuous real-time data to the Ministry (see **Figure 3-3**). The data were reviewed by staff on a daily basis and validated where necessary. Several quality assurance/quality control (QA/QC) checks and balances were carried out to ensure the validity of the data. Once the data were verified and approved they were stored in the Ministry's corporate database (Air Quality Information System – AQUIS).

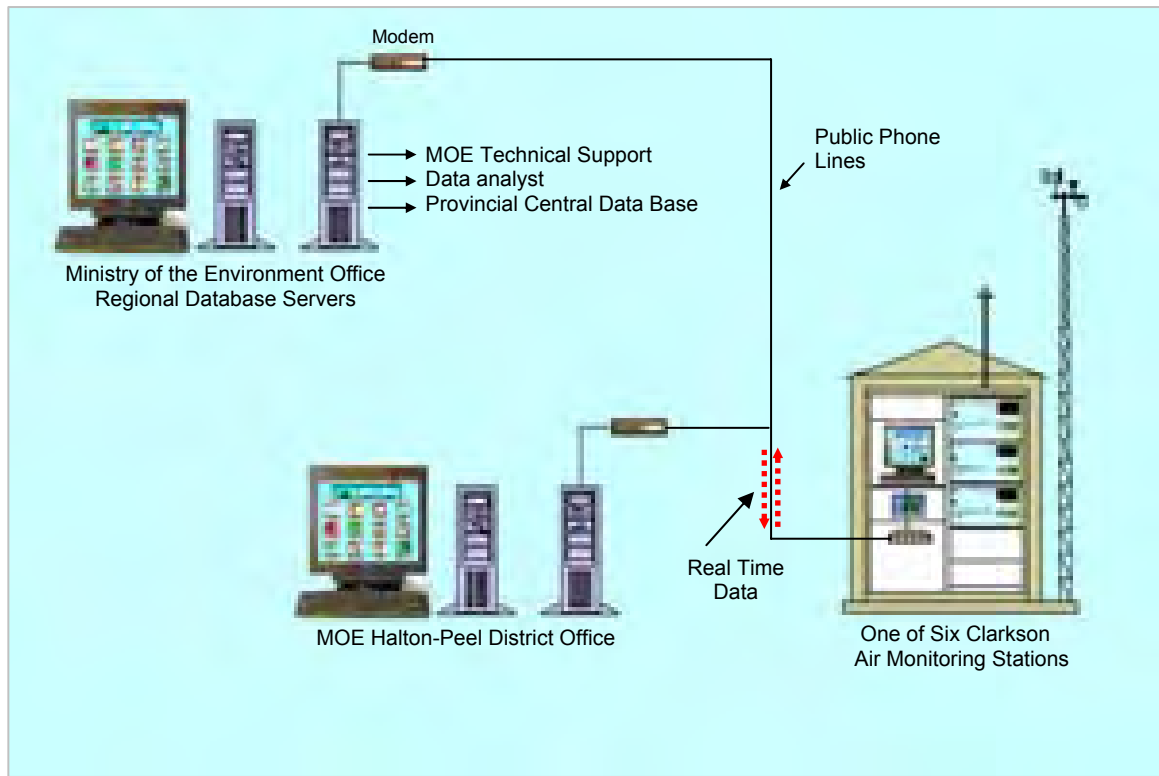
### 3.2 Data Review and Assessment Methodology

Pages 3-10 and 3-11 of this Section contain several examples of graphical illustrations and statistical calculations used to summarize, assess and interpret the large amount of data generated during this study. Illustrations, along with a detailed explanation of the approach, are provided.

Full data summary reports will be provided in various appendices.

**APPENDIX "1"** Continuous data summary  
PM<sub>2.5</sub>, NO, NO<sub>2</sub> and NO<sub>x</sub>

**APPENDIX "2"** VOC data summary

**Figure 3-3 Telemetry and Data Acquisition System**

**Table 3-1 List of Ambient Air Equipment Used in Clarkson Ambient Air Monitoring Program**

STATION	MOE STATION #	EC-NAPS STATION #	LOCATION	CONTINUOUS (HOURLY)							NON-CONTINUOUS EVERY 6 <sup>TH</sup> or 12 DAY SAMPLING				
				AQI	SO2	NO-NO2	O3	CO	PM2.5	MET	PM10	PM2.5	TSP	VOC	PAH
BURLINGTON	44008	063001	HWY 2 & NORTH SHORE BLVD	X	X	X	X	X	X						
OAKVILLE	44015	061602	BRONTE RD / WOBURN	X	X	X	X	X	X					X	
OAKVILLE	44075	*	9 <sup>TH</sup> LINE / NORTH OF QEW			X			X	X	X		X	X	
OAKVILLE	44080	*	MTO RD SOUTH SHERIDAN WAY / QEW			X					X	X		X	
OAKVILLE	44086	*	DEER RUN, WEST OF WINSTON CHURCHILL BLVD			X			X		X		X	X	
OAKVILLE	44083	*	SOUTH OF FORD DR, WEST OF ROYAL WINDSOR DR			X					X	X		X	
MISSISSAUGA	46128	*	ROYAL WINDSOR / WINSTON CHURCHILL			X			X		X		X	X	
MISSISSAUGA	46117	*	MEADOWWOOD PARK / EAST OD SOUTHDOWN			X					X	X		X	
MISSISSAUGA	MET	*	CLARKSON STP / LAKESHORE							X					

\* Clarkson Airshed Study – Ambient Air Monitoring Network

MOE Ontario Ministry of the Environment  
 EC Environment Canada  
 NAPS National Air Pollution Surveillance Network  
 AQI Provincial Ministry of the Environment, Air Quality Index Station  
 SO2 Sulphur Dioxide  
 NO Nitric Oxide  
 NO2 Nitrogen Dioxide  
 O3 Ozone  
 CO Carbon Monoxide  
 PM2.5 Fine Respirable Particulate Matter (Continuous)  
 PM2.5 Fine Respirable Particulate Matter (Non-Continuous Size Selective Inlet-SSI)  
 PM10 Inhalable Particulate Matter (Non-Continuous Size Selective Inlet-SSI)  
 TSP Total Suspended Particulates (Non-Continuous < 44 um size)  
 VOC Volatile Organic Compounds  
 PAH Polycyclic Aromatic Hydrocarbons  
 MET Meteorological Station (Wind speed, Wind direction and Temperature)

3-6

## Clarkson Air Monitoring Stations



STN 44075 QEW West - 9th line and North of QEW- OAKVILLE



STN 44083 Ford Dr.- south of Ford Dr, West of Royal Windsor Dr.- Oakville



3-7

## Clarkson Air Monitoring Stations



STN 44080 QEW East - MTO Rd, south Sheridan Way, QEW- Oakville



STN 44086 Residential - Deer Run, South Winston Churchill Blvd Dr. Oakville

3-8

## Clarkson Air Monitoring Stations



STN 46117 Industrial East - Meadowood Park- Mississauga



STN 46128 Industrial Centre - Royal Windsor Dr. / Clarkson STP- Met Station

3-9

## Clarkson Air Monitoring Stations

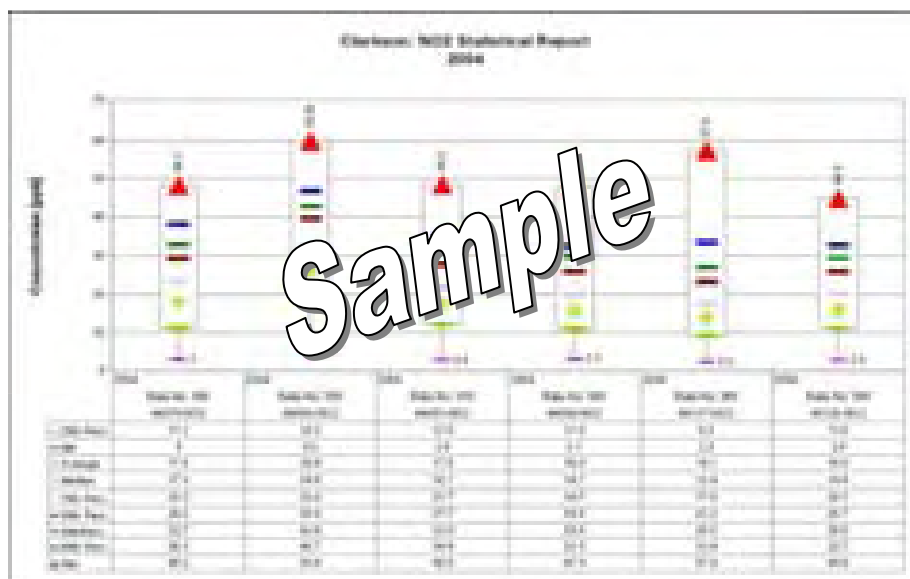


VOC Sampler and Canister (1 in 6 day sampling cycle)



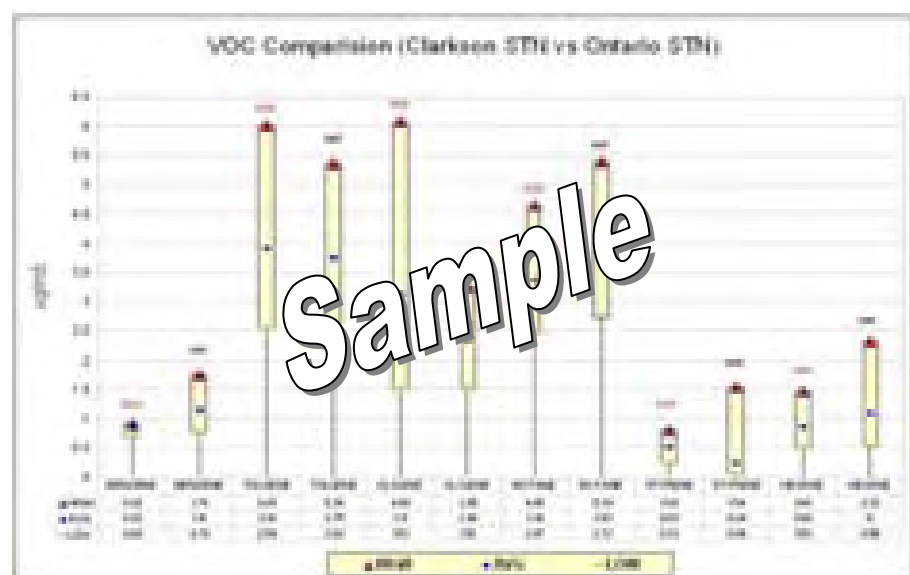
Particulate samplers PM10, PM2.5 and TSP (1 in 6 day sampling cycle)

## Data Review and Assessment Methodology



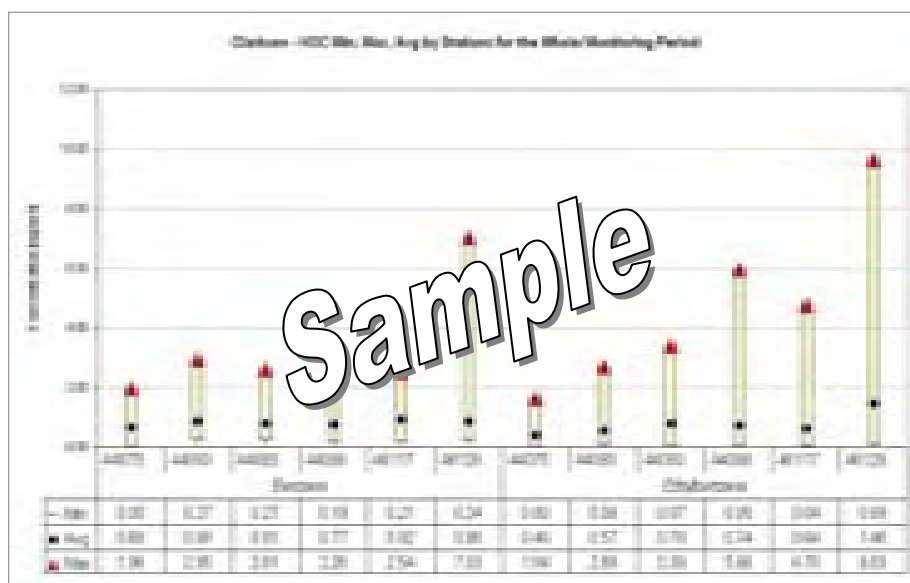
### Pollutant Line Graphs

Line graphs provide a visual data summary for a particular pollutant at each of the six monitoring stations. This graph illustrates the highest (Max) and lowest (Min) 24-hour average concentrations that were recorded and the overall average value over the monitoring period. The percentile values are calculated concentrations that provide information about the distribution of one-hour ambient air concentrations over a year.



### VOC Comparison

The Clarkson Airshed VOC data has been compared to 12 Ontario National Air Pollution Surveillance (NAPS) stations. NAPS stations are a network of Environment Canada operated stations and provide VOC measurements that we can use to compare with data from the Clarkson stations. The graph compares the average of twelve Ontario stations (ONT) to the average of the six Clarkson stations (CAS). This graph illustrates the highest (Max) and lowest (Min) 24-hour average concentrations that were recorded and the overall average value over the monitoring period.



### VOC Line Graphs

VOC line graphs are similar to the pollutant line graphs but are specific to the various Volatile Organic Compounds measured. This graph illustrates the highest (Max) and lowest (Min) 24-hour average concentrations that were recorded and the overall average value over the monitoring period. The monitoring period is defined as a calendar year, specifically 2004 or over the entire study period from June 2003 through to March 2005.

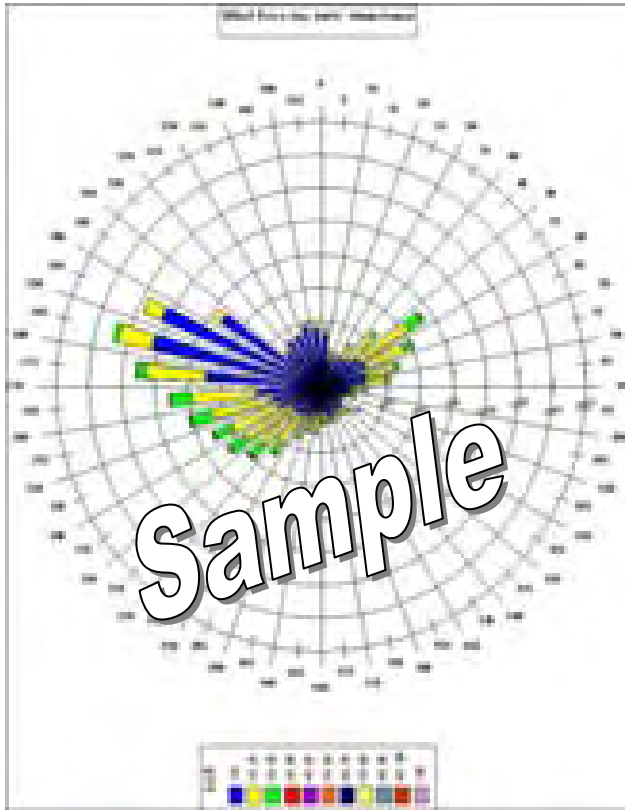
This example illustrates the maximum, lowest and average concentration for both Benzene and Ethyl benzene.

## Data Review and Assessment Methodology

### Wind Rose

A Wind Rose is a circular diagram showing the distribution of winds experienced at a given location. It simply illustrates the wind frequency from each compass direction (36 sectors). The longer the bar,

### Wind Rose

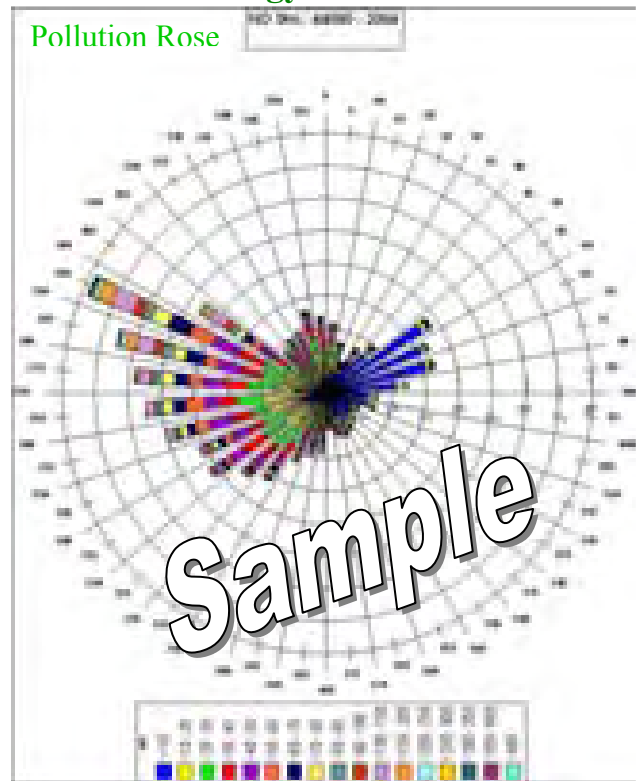


the greater percentage of time the wind originates from that specific wind direction. The various colours indicate the wind speed and percentage of time from that direction. In the above example, the most frequent wind direction would be 285 degrees, indicating that the wind is coming from a West, Northwest wind direction. The majority of the winds from this specific wind direction traveled between 0-10 km/hr (blue). The least frequent wind direction is between 115 and 125 degrees (e.g. from a East, Southeast direction).

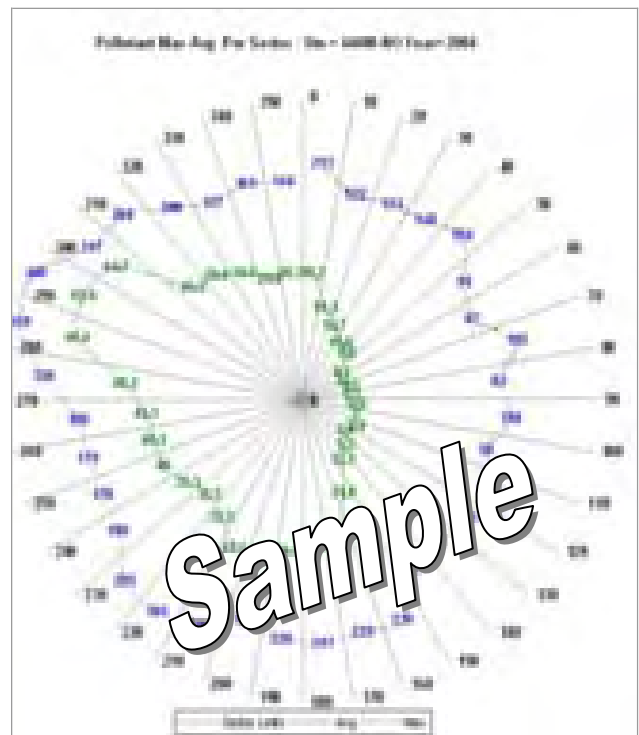
### Pollution Rose

A Pollution Rose, similar to a Wind Rose looks at the wind frequency from each compass direction (36 sectors) along with the average pollutant concentration for each specific wind sector. Wind speed is not used in this calculation. A pollution rose is very useful when assessing emission sources. In the example shown for Nitric Oxide (NO), the most frequent wind direction is 295 degrees. NO is measured hourly with an average concentration for each specific wind sector indicated by the colour. The lowest NO values (0-10ppb) occur with wind ranging from 35 to 85 degrees.

### Pollution Rose



**Wind Sector Data Plot** displays the maximum 1-hour pollutant concentration and the average concentration over the monitoring period for wind originating from each direction (36 sectors). The maximum NO concentration was 460 ppb from 290 degrees. The highest average concentration was also from that direction.



## *Section - Four*

# Pollutant Description and Monitoring Methodology

## Clarkson Airshed Study: Part II - The Ambient Air Monitoring Program

### 4.0 General

This Section of the report provides details on the nature of each target pollutant and the method by which each has been measured as part of the overall CAS air monitoring program.

Details on the results of the monitoring for each of the target pollutants are discussed in upcoming Sections of the report. These Sections include brief summaries of the monitoring approach and as such, help to tie this part of the report (Section Four) to Sections Five through Seven.

It is also important also to understand that, since there are two types of monitoring used in the program: continuous and non-continuous; the term ‘monitoring’ has a slightly different connotation for each.

In the case of continuous monitoring, which was used for PM<sub>2.5</sub>, NO<sub>x</sub>, NO and NO<sub>2</sub>, the monitor itself does both the sample collection and the analysis. This provides what is referred to as a real-time measurement, as it is sampling continuously and measuring at frequent intervals.

In the case of non-continuous monitoring, there are two steps which make up the ‘monitoring’: (i) sample collection and (ii) laboratory analysis. For each of the target pollutants measured using non-continuous monitoring (i.e. PM<sub>2.5</sub>, PM<sub>10</sub>, TSP and VOCs) the discussion on monitoring covers both sample collection and analysis.

In selecting monitoring equipment and approaches for this program, the Ministry

took a balanced look at both available technology and cost-effectiveness. Within these constraints, the Ministry defined a monitoring program that would produce representative data for the CAS study area.

## 4.1 Particulate Matter

Airborne particulate matter is the general term used to describe a mixture of microscopic solid particles suspended in air. Particulate matter includes aerosols, smoke, fumes, dust, fly ash and pollen. Its composition varies with origin, residence time in the atmosphere, time of year and environmental conditions. Fine particulate matter (PM<sub>2.5</sub>) may also be formed indirectly through a series of complex chemical reactions in the atmosphere and directly through fuel combustion (e.g. motor vehicles, power generation, industrial facilities, residential home heating furnaces, fireplaces and wood stoves, agricultural burning and forest fires).

Particulate matter is characterized according to its aerodynamic size, mainly because of the different health effects associated with particles of different diameters.

**Respirable particulate matter or fine particulate matter** refers to particles that are less than or equal to 2.5 micrometers or microns (µm) in diameter and may penetrate deep into the respiratory system. These particles are noted throughout the report as PM<sub>2.5</sub>.

**Inhalable particulate matter** refers to particles less than or equal to 10 µm in diameter and represents up to 60 per cent of the **suspended particulate matter** in the atmosphere. Inhalable particulate matter is comprised of both coarse particles [diameter 2.6 to 10.0 µm] and fine particles [diameter < 2.5 µm] and is noted throughout the report as PM<sub>10</sub>.

**Suspended particulate matter (SPM)** is a complex, multi-phase accumulation of all airborne solid and low vapor pressure liquid

particles having aerodynamic particle sizes from less than 0.01 to greater than 100 µm (microns). Historically, SPM measurements have focused on **total suspended particulates (TSP)**, which are generally 44µm or less in size. TSP will therefore be used throughout this air monitoring report, whereas SPM is a term which is only included in this discussion of particulate matter for completeness and is not used further in the report.

A major proportion of airborne PM<sub>2.5</sub> measured in southern Ontario is of trans-boundary origin. During periods of widespread elevated levels of PM<sub>2.5</sub>, it is estimated that more than 50 per cent of fine particulate matter in Ontario originates from the U.S. The U.S. contribution to PM<sub>2.5</sub> concentrations in border cities is estimated to be as high as 90 per cent.

Hospital admissions and several serious health effects, including premature death, have been found to correlate well with increased exposure to PM<sub>2.5</sub>. People with asthma, cardiovascular or lung disease, as well as children and elderly people, are considered to be the most sensitive to PM<sub>2.5</sub>. Adverse health effects have been associated with exposure to PM<sub>2.5</sub> during both short periods such as a single day, and longer periods of a year or more. Respirable particulate matter may also be responsible for environmental impacts such as corrosion, soiling, and damage to vegetation and reduced visibility.

As a result of the demonstrated health effects noted above, PM<sub>2.5</sub> is given special focus in this report and is dealt with in much more detail than PM<sub>10</sub> and TSP.

### 4.1.1 Monitoring of Particulate Matter

Ambient air monitoring for particulate matter was carried out as part of this program on a real-time/continuous and on a non-continuous basis.

Continuous monitoring for PM<sub>2.5</sub> was carried out at three of six monitoring stations (*Stn QEW*



*East, Stn Residential, and Stn Industrial East*). Non-continuous particulate monitoring for PM<sub>2.5</sub> was carried out at the other three CAS stations (*Stn QEW West, Stn Ford Dr., and Stn Industrial Centre*). Both PM<sub>10</sub> and TSP concentrations were measured using only non-continuous monitors.

All particulate matter monitors (ie. for PM<sub>2.5</sub>, PM<sub>10</sub> and TSP) were strategically located throughout the study area to ensure as complete coverage as possible with respect to potential emission sources.

Continuous monitoring of PM<sub>2.5</sub> was carried out using a Tapered Element Oscillating Microbalance (TEOM) device which is designed to handle this particle size and record real time hourly concentrations of the particles in micrograms per cubic meter (µg/m<sup>3</sup>).

Non-continuous monitoring to collect samples of the various size fractions of particulate matter (PM<sub>2.5</sub>, PM<sub>10</sub>, and TSP) was done using selective size inlet (SSI) hi-volume samplers or “hi-vols”. This method allowed separation of the size fractions prior to collection on the sample filter. The “hi-vol” sampler is a commonly used device consisting of a blower and a filter which is usually operated in a standard shelter to collect a 24 hour sample.

The flow rate of air through the “hi-vol” filter was controlled and maintained at 40 cubic feet per minute (CFM) using a mass flow controller. All samples were collected on pre-weighed quartz or glass fiber filters which were then analyzed for particle mass concentration. The particle mass concentration was reported in µg/m<sup>3</sup>. Samples were collected every sixth day over a 24 hour period (midnight to midnight) following the National Air Pollution Surveillance (NAPS) sampling schedule.

The Ministry’s Laboratory Services Branch carried out particulate matter analysis on all non-continuous samples.

## 4.2 Volatile Organic Compounds (VOCs)

VOCs are emitted into the atmosphere from a variety of anthropogenic and natural sources. Some of the major anthropogenic sources include vehicles, fossil fuel combustion, steel-making, petroleum refining, fuel-refilling, industrial and residential solvent use, paint application, manufacturing of synthetic materials (e.g. plastics, carpets), food processing, agricultural activities, wood processing and wood burning. Vegetation sources are the main contributor of natural VOC emissions.

Certain VOCs warrant special attention because they play an important role in the formation of ground-level ozone and PM<sub>2.5</sub>. VOCs that contribute to the formation of ozone typically have a short life span in the atmosphere. In contrast, VOCs that are least reactive to ozone formation are capable of being transported very long distances as they have a long half-life in the troposphere.

### 4.2.1 Monitoring of VOCs

Specialized, non-routine sampling and analytical techniques are required to measure VOCs because they are usually present in the atmosphere in extremely low concentrations.

The sampling of VOCs was carried out at all six CAS air monitoring stations. Samples were collected every sixth day over a 24-hour period (midnight to midnight), following the National Air Pollution Surveillance (NAPS) sampling schedule, by drawing ambient air into an evacuated stainless canister.

Ministry field personnel carried out the collection and shipping of VOC samples to the Environment Canada Organics Laboratory in Ottawa for analysis.



Analysis was carried out using Gas Chromatography / Mass Spectrometry (GC/MS). Concentrations for 153 'routine' VOCs were reported for each sample. An additional 36 compounds were selectively analyzed. The NAPS target compound list of a 189 VOCs is identified in **Table 7-1**.

It is important to note that VOCs are defined here as organic compounds having a vapour pressure greater than  $10^{-1}$  torr [1 mm of mercury (Hg)] at 25 degrees C and 760 mm Hg. The target compounds measured using the above mentioned method contain no more than twelve carbon atoms. The detection of methane, ethane, ethylene, and acetylene, as well as VOCs containing carbonyl groups, falls under the scope of different analytical methods and were not included in this study.

### 4.3 Nitrogen Oxides

Nitrogen dioxide ( $\text{NO}_2$ ) is a reddish-brown gas with a pungent and irritating odour.  $\text{NO}_2$  plays a major role in atmospheric reactions that produce ground-level ozone, a major component of smog.  $\text{NO}_2$  is also a precursor to the formation of nitrates ( $\text{NO}_3$ ), which contribute to levels of fine particulate matter in the atmosphere.

All combustion processes conducted in the presence of air, produce nitrogen oxides ( $\text{NO}_x$ ), of which  $\text{NO}_2$  is a significant component. Major sources of  $\text{NO}_x$  emissions include the transportation sector, fossil fuel power generation, primary metal production and incineration.

Nitric oxide ( $\text{NO}$ ) is a precursor to the formation of ozone,  $\text{NO}_2$  and  $\text{NO}_3$ .  $\text{NO}$  is usually emitted from combustion processes. Once emitted,  $\text{NO}$  is converted to  $\text{NO}_2$  in the atmosphere which then becomes involved in photochemical processes and/or fine particulate formation.

$\text{NO}_2$  can irritate the lungs, lowering the resistance in humans to respiratory infection. People with asthma and bronchitis have

increased sensitivity to  $\text{NO}_2$ . This nitrogen compound chemically transforms into nitric acid ( $\text{HNO}_3$ ) in the atmosphere and, when deposited, contributes to lake acidification.  $\text{HNO}_3$  can also corrode metals, fade fabrics, degrade rubber, and damage trees and crops.

#### 4.3.1 Monitoring of Nitrogen Oxides

Continuous monitoring for nitrogen oxides at all six stations was carried out using the chemiluminescence detection principle. Analyzers using this principle reflect the fact that nitric oxide ( $\text{NO}$ ) and ozone ( $\text{O}_3$ ) react to produce a characteristic luminescence with an intensity linearly proportional to the  $\text{NO}$  concentration.

$\text{NO}_2$  must first be transformed into  $\text{NO}$  before it can be measured using the chemiluminescence detection method.  $\text{NO}_2$  is converted within the analyzer or monitor to  $\text{NO}$  using a molybdenum  $\text{NO}_2$ -to- $\text{NO}$  converter heated to about 325 degrees C.

The analyzers as used in the Clarkson ambient air monitoring program continuously recorded concentrations of the following: nitric oxide ( $\text{NO}$ ), nitrogen dioxide ( $\text{NO}_2$ ) and nitrogen oxides ( $\text{NO}_x$ ).

### 4.4 Meteorological Data Measurement

Meteorological information for this study was obtained from four locations: i) Toronto Pearson airport, ii) Toronto Island airport, iii) Clarkson *Stn QEW East* and, iv) Clarkson Sewage Treatment Plant (Stn #44066).

Hourly data was acquired from each location in order to develop both wind rose and pollution rose information.

Wind speed and wind direction data were correlated with pollutant concentration data to

assist in assessing potential industrial sources which may have been contributing to the air quality of CAS study area.

## *Section - Five*

# Particulate Matter (PM<sub>2.5</sub>, PM<sub>10</sub>, TSP)

## Clarkson Airshed Study: Part II - The Ambient Air Monitoring Program

### 5.0 Summary of Monitoring for Particulate Matter

Airborne concentrations of total suspended particulates (TSP), inhalable particulate matter (PM<sub>10</sub>) and respirable particulate matter (PM<sub>2.5</sub>) were measured at selective air monitoring stations throughout the CAS study area using both non-continuous and continuous monitoring techniques.

Non-continuous monitoring was carried out at three of the six CAS stations using standard inlet hi-vols for TSP and using hi-vols modified with size selective inlets (SSI) for PM<sub>2.5</sub>. PM<sub>10</sub> monitoring was completed at each of the six stations using modified hi-vols with SSI. Daily 24 hour samples were collected on a 1 in 6 day sampling schedule for all the above mentioned hi-vols.

Real-time continuous PM<sub>2.5</sub> monitoring was also carried out at three CAS stations throughout the 22 month monitoring period.

[Note: Details on the monitoring of Particulate Matter can be found in Section – Four entitled

Pollutant Description and Monitoring Methodology].

### 5.1 Discussion of Monitoring Results

Statistical data summaries (referred to as “statistical reports”) were prepared to illustrate the minimum, maximum, average, and various percentile concentrations (including 98<sup>th</sup>) for PM<sub>2.5</sub> and PM<sub>10</sub> at each station. Two of these statistical reports are provided for each parameter, one for the year 2004 and one for the “whole period” (2003-2005).

As noted in Section – Four, the focus of our attention on Particulate Matter has been directed to PM<sub>2.5</sub>. PM<sub>2.5</sub> is understood to represent the key health concern of the three particulate matter ‘fractions’ identified and it is for this reason that it is examined in detail in the discussion which follows.

Pollution roses and wind sector data using hourly PM<sub>2.5</sub> concentration values played a key role in our assessment as a means of identifying

pollutant dispersion patterns and to help evaluate the impact from the various sources.

Summary data for PM<sub>10</sub> and TSP are also provided and discussed below.

A general description of the above mentioned statistical reports and how they were developed can be found in Section – Three of this report.

Ministry Air Quality Index (AQI) network data and smog advisory days were also considered in the review of the PM<sub>2.5</sub>, PM<sub>10</sub> and TSP data.

### 5.1.1 Respirable Particulate Matter (PM<sub>2.5</sub>)

In 2000, the Canadian Council of Ministers of the Environment (CCME), developed a Canada-Wide Standard (CWS) for PM<sub>2.5</sub> as a result of the potential for this pollutant to have an adverse effect on human health and the environment. As referenced in the Guidance Document on Achievement Determination (GADD), the CWS for PM<sub>2.5</sub> is 30 micrograms per cubic metre (µg/m<sup>3</sup>). The CWS is defined in terms of a 24 hour averaging time and is based on the 98<sup>th</sup> percentile annual ambient measurement averaged over three consecutive years. Jurisdictions are required to meet the PM<sub>2.5</sub> CWS by 2010. However, comprehensive reporting on progress toward meeting this CWS commences in 2006.

In order to provide a comparative quantitative assessment of CAS study area PM<sub>2.5</sub> concentrations, the Ministry has used the CWS value of 30 µg/m<sup>3</sup> as a *project benchmark concentration*. The 24 hr annual average 98<sup>th</sup> percentile CAS study area PM<sub>2.5</sub> values have been compared to this *benchmark*.

It is important to emphasize that the 24 hr 98<sup>th</sup> percentile values used in compiling the annual averages for 2004 and for 2003-2005 (see **Table 5-1**) consisted of data from both continuous (TEOM) and non-continuous (hi-vols) monitors. In this regard, 24 hr hi-vol PM<sub>2.5</sub> concentrations [available from 1 – 24 hour sample taken every 6 days at three monitoring stations] and a 24 hr average of TEOM PM<sub>2.5</sub> concentrations

[available from 24 – 1 hr sample readings taken continuously at the remaining three stations] are used in determining the overall annual average 98<sup>th</sup> percentile values for each of the six monitoring stations.

**Figure 5-1** is the statistical report for the six CAS stations based on 24 hour 2004 data for PM<sub>2.5</sub>. The 98<sup>th</sup> percentile value for the complete year ranged from 26.3 µg/m<sup>3</sup> at *Stn Industrial Centre* to 43.0 µg/m<sup>3</sup> at *Stn QEW East*. The average 98<sup>th</sup> percentile concentration for all monitoring stations was 34.0 µg/m<sup>3</sup>. Four of the six sites exceeded the *project benchmark concentration* for PM<sub>2.5</sub> of 30 µg/m<sup>3</sup>.

**Figure 5-2** represents the statistical report for the six CAS stations based on 24 hour PM<sub>2.5</sub> data compiled over the whole study period (June 2003 to March 31, 2005). The 98<sup>th</sup> percentile value for the complete study period ranged from 25.2 µg/m<sup>3</sup> at *Stn Industrial Centre* to 40.7 µg/m<sup>3</sup> at *Stn QEW East*. The average 98<sup>th</sup> percentile concentration for all monitoring stations was 32.8 µg/m<sup>3</sup>. As was the case for 2004, four of the six sites exceeded the *project benchmark concentration* for PM<sub>2.5</sub> of 30 µg/m<sup>3</sup>.

Notwithstanding the elevated PM<sub>2.5</sub> annual average concentrations as compared to the *project benchmark* value, a review of ‘raw’ PM<sub>2.5</sub> data (see Appendix 1) for each of the same four monitoring sites as noted above, indicates that there were some 60 individual 24 hour sampling results (either one 24 hour non-continuous result from a hi-vol or an average of 24 one hour continuous results from a TEOM) that were equal to or greater than 30 µg/m<sup>3</sup> over the whole period (2003-2005). About 85 % of these elevated PM<sub>2.5</sub> concentrations occurred during smog “events”. Despite the fact that these data do not represent 98<sup>th</sup> percentile values and cannot be reasonably compared to the *project benchmark concentration* (based on an annual average), they are somewhat of an indicator that smog events play a measurable role in defining elevated PM<sub>2.5</sub> concentrations throughout the CAS study area.

**Table 5-1** compares; (i) the 24 hour average measured PM<sub>2.5</sub> concentrations for 2004 with those of the whole study period (2003-2005), as well as (ii) the 98<sup>th</sup> percentile values for 2004 with those of 2003-2005. All these values compare well and are indeed similar.

The annual average 24 hour PM<sub>2.5</sub> concentration in 2004 ranged from 6.4 µg/m<sup>3</sup> at *Stn Industrial East* to 12.8 µg/m<sup>3</sup> at *Stn QEW East*. The average 24 hour PM<sub>2.5</sub> measurement for all monitoring stations was 9.7 µg/m<sup>3</sup> in 2004. The maximum values at all stations across the study area were fairly consistent and ranged from 40µg/m<sup>3</sup> to 45 µg/m<sup>3</sup>.

**Table 5-1 Station by Station Comparison of PM<sub>2.5</sub> Concentrations in Study Area 2004 and 2003/2005.**

STN	AVERAGE		98 <sup>TH</sup> PERCENTILE	
	2004	2003-2005	2004	2003-2005
QEW West	8.0 µg/m <sup>3</sup>	8.4 µg/m <sup>3</sup>	33.8 µg/m <sup>3</sup>	31.8 µg/m <sup>3</sup>
QEW East	12.8µg/m <sup>3</sup>	14.0 µg/m <sup>3</sup>	43.0 µg/m <sup>3</sup>	40.7 µg/m <sup>3</sup>
Ford Dr	10.8 µg/m <sup>3</sup>	11.7 µg/m <sup>3</sup>	38.0 µg/m <sup>3</sup>	39.1 µg/m <sup>3</sup>
Res.	8.7 µg/m <sup>3</sup>	8.8 µg/m <sup>3</sup>	34.3 µg/m <sup>3</sup>	32.5 µg/m <sup>3</sup>
Ind. East	6.4 µg/m <sup>3</sup>	6.9 µg/m <sup>3</sup>	28.4 µg/m <sup>3</sup>	27.4 µg/m <sup>3</sup>
Ind. Centre	11.2 µg/m <sup>3</sup>	11.3 µg/m <sup>3</sup>	26.3 µg/m <sup>3</sup>	25.2 µg/m <sup>3</sup>
AVG for All Stns	9.7 ug/m <sup>3</sup>	10.2 ug/m <sup>3</sup>	34.0 ug/m <sup>3</sup>	32.8 ug/m <sup>3</sup>

The 24 hour average PM<sub>2.5</sub> concentration for all stations over the whole study period (2003-20035) was 10.2 µg/m<sup>3</sup>. This value is 5% higher than the average concentration of 9.7 µg/m<sup>3</sup> which was measured during 2004. The whole study period characteristically includes more summer days and these tend to contribute to the increase in the PM<sub>2.5</sub> values as compared to 2004.

Following the comment above, it is well documented that PM<sub>2.5</sub> concentrations vary between summer and winter months. Data obtained during the CAS air monitoring program were assessed seasonally for both the summer months (May to September) and the winter months (January to April, October to December)

in order to quantify this variance. Only sites that reported a full year of consecutive data (2004) were assessed for summer and winter comparisons.

**Table 5-2** summarizes the seasonal PM<sub>2.5</sub> data for 2004. The average concentration in the summer months (10.6 µg/m<sup>3</sup>) was 86% higher than the average concentration for the winter months (5.7 µg/m<sup>3</sup>). This seasonal difference is likely attributed to summer smog events.

PM<sub>2.5</sub> annual average concentrations at the six CAS stations were compared to 12 selected

**Table 5-2 Seasonal PM2.5 Concentrations**

2004	SUMMER	WINTER
AVERAGE	10.6 µg/m <sup>3</sup>	5.7 µg/m <sup>3</sup>
98% PERCENTILE	44.0 µg/m <sup>3</sup>	21.0 µg/m <sup>3</sup>
MAXIMUM (Hr)	96.0 µg/m <sup>3</sup>	67.0 µg/m <sup>3</sup>

Ministry AQI in key Ontario urban areas. The Simcoe AQI station was also used as a likely indicator of long range transport concentrations entering Ontario from the US.

The sites used included: Toronto (2), Mississauga, Brampton, Burlington, and Hamilton as wells as Sarnia, London, Windsor, Kitchener and Ottawa.

In 2004, at *Stn QEW East* the calculated annual average PM<sub>2.5</sub> concentration was 12.8 µg/m<sup>3</sup> (**Figure 5-3**) which was the highest value of all the AQI stations compared.

It is important to note that in making this comparison, the Clarkson air-monitoring stations, especially *Station QEW East* and *Stn Industrial Centre*, were intended to assess specific sources such as vehicular and industrial emissions. The Ontario AQI stations, however, were used by the Ministry to assess general air quality in an area and were not intended to focus on impacts from specific point sources. The comparison of CAS study area PM<sub>2.5</sub> with data obtained from the AQI stations has been

included simply to give context to the CAS study area data.

### 5.1.1.1 Wind Sector Data Assessment for PM<sub>2.5</sub>

#### (a) The Approach:

Data from the three continuous PM<sub>2.5</sub> TEOM analyzers (those located at *Stn QEW West*, *Stn Residential* and *Stn Industrial East*) were correlated with hourly meteorological data. Only the continuous instruments were used since only these instruments generated 1 hour concentrations that could be compared with hourly wind direction measurements. In order to determine the most common wind directions that correlated with the highest pollutant concentrations, the 360 degree compass was divided into 10 degree *wind sectors*.

Wind rose and pollution roses as well as maximum and average sector PM<sub>2.5</sub> concentrations for 2004 were used to assess the effect that meteorological conditions had on potential sources of respirable particulates within the CAS study area. This same approach was also used to define the primary wind direction that assists long-range transport of PM<sub>2.5</sub> in having an impact on the CAS study area.

Using this wind sector approach, two key PM<sub>2.5</sub> values for each sector were determined: (i) the *maximum sector* concentration, which is the highest hourly value recorded from each particular wind sector, and (ii) the *average sector* concentration which is the average value calculated for each wind sector. These concentrations are calculated per sector per year.

#### (b) The Results:

##### *Stn QEW West*

At *Stn QEW West*, predominant winds were from the southwest - west northwest (sectors 210 to 310 degrees) (**Figures 5-4A and 5-4B**). These wind directions did not correlate well with either the peak PM<sub>2.5</sub> average sector concentration or

the highest PM<sub>2.5</sub> maximum sector concentration. However, there was some overlap of the maximum values into this predominant wind sector range.

The 190 to 200 degree wind sector yielded the highest average sector PM<sub>2.5</sub> concentration of 18.7 µg/m<sup>3</sup>. This concentration likely reflects industrial operations in the south and southeast part of the study area, with some input from the QEW and long-range transport.

The maximum sector PM<sub>2.5</sub> concentrations of 60-70 µg/m<sup>3</sup> were contributed more from the west - south southwest winds in sectors 190 to 270 degrees. These wind sectors are indicative of long range transport and possibly some residential fuel burning. It is also important to note that there was another high maximum sector PM<sub>2.5</sub> concentration of 67 µg/m<sup>3</sup> which came out of wind sector 90-100 degrees and this was likely a result of inputs from the QEW.

Smog events tend to be a key issue in the CAS study area when prevailing winds are from the southeast - southwest.

Wind sectors in the range of 320 to 0 degrees (north – north northwest) are most closely correlated with both the lowest annual sector PM<sub>2.5</sub> concentration (4.0 to 4.6 µg/m<sup>3</sup>) and the lowest maximum sector PM<sub>2.5</sub> concentrations (17 and 24 µg/m<sup>3</sup>). These values could reflect background QEW impacts and/or background residential impacts.

##### *Stn Residential*

At *Stn Residential*, the predominant winds were from west southwest - north in wind sectors 250 around to 10 degrees (**Figures 5-5C and 5-5D**). With the close proximity of this station to Lake Ontario, PM<sub>2.5</sub> concentrations are impacted somewhat differently by meteorological conditions in this area than they are for monitoring stations located near the QEW highway. Winds in this area generally prevail from the north.



The highest maximum sector  $PM_{2.5}$  concentration of  $96 \mu\text{g}/\text{m}^3$  occurs in wind sector 330 to 340 degrees and in wind sector 120 to 130 degrees. The 330 to 340 sector is representative of predominant wind direction and reflective of input from local industrial facilities northwest to north of *Stn Residential* while the 120 to 130 sector is likely due to industries to the east – southeast and possibly some input from long range transport.

However, wind sectors in the south - southwest (180 to 230 degrees), which were comparable to those that showed the highest average sector  $PM_{2.5}$  concentrations for *Stn QEW West*, also created the highest annual average  $PM_{2.5}$  concentrations at *Stn Residential* (17 and  $18.1 \mu\text{g}/\text{m}^3$ ). As in the case of *Stn QEW West*, this likely indicates an impact from long-range transport.

The lowest annual average sector and lowest maximum sector  $PM_{2.5}$  concentrations at *Stn Residential* of  $5.0 - 5.8 \mu\text{g}/\text{m}^3$  and 36 to  $39 \mu\text{g}/\text{m}^3$  respectively, originated from wind sectors 310 to 20 degrees. These values may be reflective of some of the open property directly north and northwest of the station and may be indicative of background conditions.

### ***Stn Industrial East***

At *Stn Industrial East*, predominant winds largely occurred from south southwest - northwest in wind sectors 300 to 340 degrees (see **Figure 5-6 E** and **5-6F**). Once again there was some correlation to the highest annual and maximum sector  $PM_{2.5}$  concentrations but some higher values were also noted on the periphery of the predominant wind sector directions.

The highest maximum sector  $PM_{2.5}$  concentration of  $85 \mu\text{g}/\text{m}^3$  occurred in wind sector 180 to 190 degrees and may be indicative of an industrial source south of the monitoring station and long range transport.

The average sector  $PM_{2.5}$  concentrations were consistently lower at this station than the other

three CAS stations used in this comparison. However, the highest average values of 15.4 to  $16.5 \mu\text{g}/\text{m}^3$  were comparable to those found at other stations and occurred in the wind sectors ranging from south to south southwest (190 to 210 degrees). These wind sectors are indicative of long range transport and local industrial source inputs.

The lowest average sector concentration and lowest maximum sector  $PM_{2.5}$  concentration of  $2.6 \mu\text{g}/\text{m}^3$  and 20 to  $23 \mu\text{g}/\text{m}^3$  respectively, occurred in wind sectors 10 to 40 degrees and reflect residential inputs.

### **5.1.2 Inhalable Particulate Matter ( $PM_{10}$ )**

Inhalable Particulate Matter ( $PM_{10}$ ), was sampled at all six CAS monitoring stations using non-continuous size selective inlet (SSI- $PM_{10}$ ) hi- vol samplers. Statistical reports were prepared to illustrate the minimums, maximums, and average concentrations for each station over

**Table 5-3: A Comparison of 24 hour Average  $PM_{10}$  Concentrations in the Study Area – 2004 and 2003/2005**

$PM_{10}$	2004	2003-05
QEW West	$18.8 \mu\text{g}/\text{m}^3$	$19.6 \mu\text{g}/\text{m}^3$
QEW East	$19.6 \mu\text{g}/\text{m}^3$	$18.8 \mu\text{g}/\text{m}^3$
Ford Dr	$18.3 \mu\text{g}/\text{m}^3$	$18.9 \mu\text{g}/\text{m}^3$
Residential	$15.4 \mu\text{g}/\text{m}^3$	$15.4 \mu\text{g}/\text{m}^3$
Ind. East	$15.4 \mu\text{g}/\text{m}^3$	$16.5 \mu\text{g}/\text{m}^3$
Ind. Centre	$19.0 \mu\text{g}/\text{m}^3$	$18.6 \mu\text{g}/\text{m}^3$
Average	$17.9 \mu\text{g}/\text{m}^3$	$18.0 \mu\text{g}/\text{m}^3$

the study period.  $PM_{10}$  data were also averaged across the six stations to obtain an average concentration for the CAS study area.

**Table 5-3** compares the 24 hour average  $PM_{10}$  concentrations in 2004 to those recorded over the whole monitoring period. (June 2003 to March 2005).

All of the PM<sub>10</sub> results discussed in this section were compared to the 24 hour average interim Ministry AAQC for PM<sub>10</sub> of 50 µg/m<sup>3</sup>.

The annual average PM<sub>10</sub> 24 hour concentration for 2004, shown in **Figure 5-7**, was consistent across the airshed, and ranged from 15.4 µg/m<sup>3</sup> at *Stn Residential* and *Stn Industrial East* to 19.6 µg/m<sup>3</sup> at *Stn QEW East* and *Stn Industrial Centre*. The annual average for the entire study area for 2004 was 17.9 µg/m<sup>3</sup>.

The annual average PM<sub>10</sub> concentration for the whole monitoring period, shown in **Figure 5-8**, was also consistent across the CAS study area, and ranged from 16.5 µg/m<sup>3</sup> at *Stn Industrial East* to 19.6 µg/m<sup>3</sup> at *Stn QEW East*. The annual average PM<sub>10</sub> concentration for the entire study area was 18.0 µg/m<sup>3</sup>.

A review of 'raw' PM<sub>10</sub> data (see Appendix 1) indicates that there were 13 individual 24 hour sampling results (based on one 24 hour hi-vol sample) that were equal to or greater than the 50 µg/m<sup>3</sup> 24 hour average interim AAQC for PM<sub>10</sub> over the whole monitoring period (2003-2005). More than 50% of these elevated PM<sub>10</sub> concentrations occurred during smog events.

### 5.1.3 Total Suspended Particulates (TSP)

As was the case with the PM<sub>2.5</sub> and PM<sub>10</sub> hi-vol samples, the total suspended particulate (TSP) samples were collected over a 24 hour period every six days (referred to as 6 day cycle). These samples were collected at the following CAS stations: (i) *Stn QEW West*, (ii) *Stn QEW East* and, (iii) *Stn Industrial East*.

**Figure 5-9**





All of the TSP results were compared to the Ministry's 24 hour average AAQC of 120  $\mu\text{g}/\text{m}^3$  and the annual AAQC of 60  $\mu\text{g}/\text{m}^3$ .

The 24 hour TSP AAQC value of 120  $\mu\text{g}/\text{m}^3$  was exceeded on four occasions with all but one of these values attributable to smog events. The 2004 annual average for the airshed was 39.8  $\mu\text{g}/\text{m}^3$  which did not exceed the TSP annual AAQC of 60  $\mu\text{g}/\text{m}^3$ . (See **Table 5-4**)

**Table 5-4 Summary of Annual TSP Recorded at 3 CAS Stations**

MOE AAQC 60 $\mu\text{g}/\text{m}^3$		
Annual average per station 2004		
QEW West	Residential	Ind. East
47.9 $\mu\text{g}/\text{m}^3$	35.7 $\mu\text{g}/\text{m}^3$	35.2 $\mu\text{g}/\text{m}^3$

The annual average for each of the 3 Clarkson stations was also below the MOE AAQC of 60  $\mu\text{g}/\text{m}^3$ .

## 5-2 Summary of Results - Observations

**Figure 5-9**, illustrates the 2004 annual 24 hour averages for both respirable particulate matter ( $\text{PM}_{2.5}$ ) and inhalable particulate matter ( $\text{PM}_{10}$ ).

In the figure, the value shown in the inner circle (light blue) represents the  $\text{PM}_{2.5}$  concentration and the value shown in the outer circle (dark blue) plus that in the inner circle, represents the  $\text{PM}_{10}$  concentration (ie. by definition  $\text{PM}_{2.5}$  fraction is included within the  $\text{PM}_{10}$  fraction).

The following observations can be made relative to the pattern or trends in  $\text{PM}_{10}$  and  $\text{PM}_{2.5}$  concentrations across the study area:

- $\text{PM}_{10}$  concentrations were fairly consistent across the CAS study area at four out of the six monitoring stations while values at the two remaining stations *Stn Residential* and *Stn Industrial East* (#44086 and #46117) were slightly lower.

- Both *Stn QEW West* (#44075) with an annual average  $\text{PM}_{2.5}$  value of 8.0  $\mu\text{g}/\text{m}^3$  and *Stn Residential* (#44086) with an annual average  $\text{PM}_{2.5}$  value of 8.7  $\mu\text{g}/\text{m}^3$ , likely represent background / residential concentrations and as such could reflect the  $\text{PM}_{2.5}$  coming into the Clarkson study area.
- *Stn QEW East* (#44080) recorded a  $\text{PM}_{2.5}$  annual average for 2004 of 12.8  $\mu\text{g}/\text{m}^3$ , which was 60% higher than the 8.0  $\mu\text{g}/\text{m}^3$  noted above for *Stn QEW West* #44075) and 51% higher than the provincial annual average for  $\text{PM}_{2.5}$  of 8.5  $\mu\text{g}/\text{m}^3$  as measured at selected AQI stations during 2004 (selected sites **Figure 5-3**).

Elevated  $\text{PM}_{2.5}$  concentrations at *Stn QEW East* likely point to vehicular emissions as being the significant source since the station is located near the QEW.

- The annual average concentrations of  $\text{PM}_{2.5}$  at both *Stn Ford Dr.* (10.8  $\mu\text{g}/\text{m}^3$ ) and *Stn Industrial Centre* (11.2  $\mu\text{g}/\text{m}^3$ ) are 24% and 29% higher than *Stn Residential* (8.7  $\mu\text{g}/\text{m}^3$ ). These values are likely attributed to local industrial emissions and some vehicular emissions.

To supplement the above findings it should be noted that the annual 24 hour 2004 average concentration for  $\text{PM}_{2.5}$  over the entire CAS study area was 9.7  $\mu\text{g}/\text{m}^3$ , which is 14% higher than selected Ontario AQI stations.

Once again, caution should be applied in interpretation since the AQI stations are situated to measure 'general' air quality, whereas the CAS stations were focused on defining source inputs to the CAS study area. Comparisons are only intended to provide context to the CAS  $\text{PM}_{2.5}$  emissions, particularly since AQI data is the only other data available with which to reasonably make a comparison.

The most telling observations from the PM (particulate matter) portion of the CAS ambient air monitoring program results, particularly in

the case of PM<sub>2.5</sub>, are evident when the measured results are compared to the Canada Wide Standard (CWS) value for PM<sub>2.5</sub> of 30 µg/m<sup>3</sup>.

As noted in Section 5.1.1, it is recognized that in comparing CAS study area PM<sub>2.5</sub> data with the CWS the 30 µg/m<sup>3</sup> value itself is used as a *project benchmark concentration* against which all PM<sub>2.5</sub> annual average concentrations were compared. This approach is not compatible with the manner in which the CWS will be 'enforced' once it is adopted in 2010. In order to document "achievement" with the CWS, data to be compared with the standard must be based on a 3 year average 24 hour 98<sup>th</sup> percentile concentration.

Using the *project benchmark concentration* approach however, does allow the Ministry to conduct a comparative quantitative analysis that highlights elevated concentrations of PM<sub>2.5</sub> measured in the study area.

The comparison of the CAS PM<sub>2.5</sub> data with the *project benchmark concentration* of 30 µg/m<sup>3</sup> yielded the following observation:

- The annual averages of 98<sup>th</sup> percentile 24 hr PM<sub>2.5</sub> concentrations for the following four CAS monitoring stations: (i) *Stn QEW West*, (ii) *Stn QEW East*, (iii) *Stn Ford Dr.*, and (iv) *Stn Residential* exceed the *project benchmark concentration* both for 2004 and for the whole study period (2003-2005). The highest value recorded was 43 µg/m<sup>3</sup> (at *Stn QEW East* in 2004) whereas the overall averages for all stations were 34.0 µg/m<sup>3</sup> in 2004 and 32.8 µg/m<sup>3</sup> during the period 2003-2005.

For these same four stations, a review of the 'raw' project PM<sub>2.5</sub> data indicates that there were 60 individual 24 hour sampling results that were equal to or greater than 30 µg/m<sup>3</sup> over the whole period (2003-2005). About 85% of these elevated PM<sub>2.5</sub> concentrations occurred during smog "events". Although these data do not represent 98<sup>th</sup> percentile annual data and are not strictly comparable to the *project benchmark*

*concentration* they do provide an indicator that smog events play a significant role in the measurement of high PM<sub>2.5</sub> concentrations in the CAS study area.

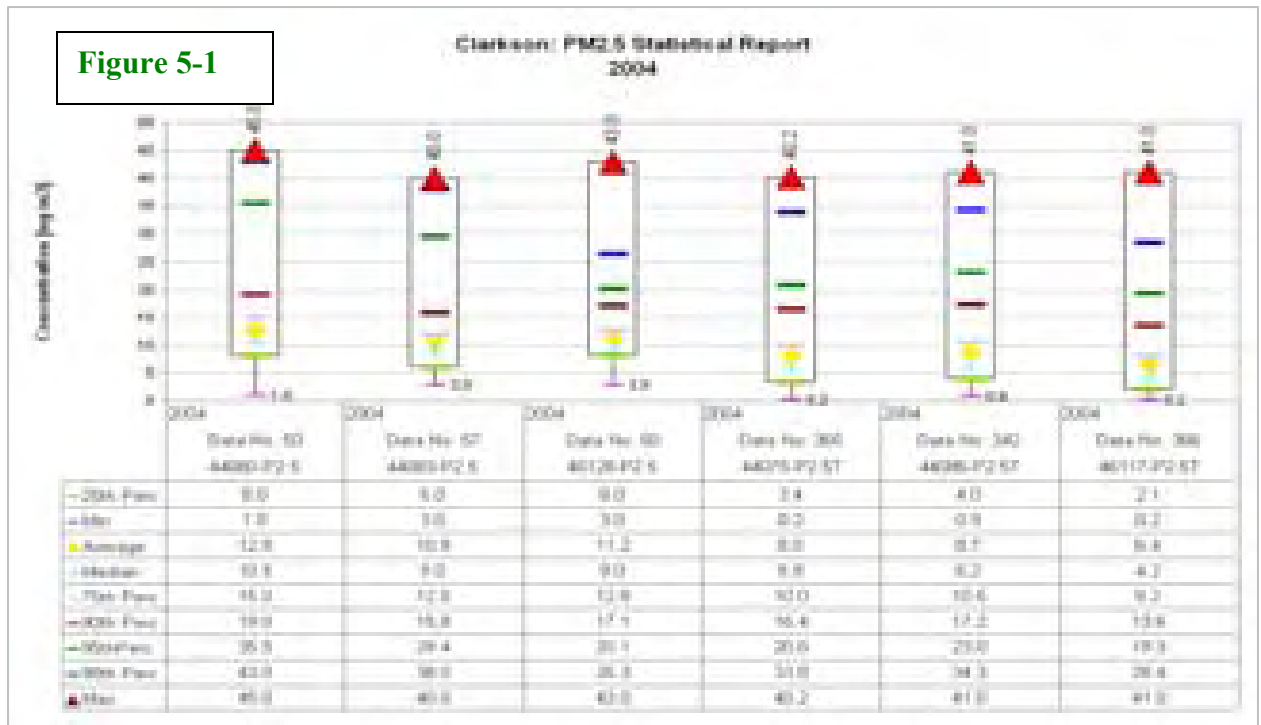
Vehicular emissions and long-range transport of air pollutants are also seen as significant factors leading to the above mentioned elevated PM<sub>2.5</sub> concentrations in the CAS study area.

It should also be noted however, that using *Stn Ford Dr* and *Stn Industrial Centres* as benchmarks, industrial emissions may contribute up to 25% of the PM<sub>2.5</sub> concentrations that were measured during the CAS study.

Also, it should be acknowledged in concluding these observations that the PM<sub>2.5</sub> concentrations are 86% higher in the summer months than in the winter months. This is primarily due to the fact that smog events largely occur during warm summer days.

Annual averages of 24 hour PM<sub>10</sub> (inhalable particulate matter) concentrations measured at each of the six stations in the CAS study area were similar to each other. Over the monitoring period there were 13 exceedances of the 50 µg/m<sup>3</sup> 24 hour interim Ministry AAQC for PM<sub>10</sub>. More than 50% of these exceedances occurred during smog events.

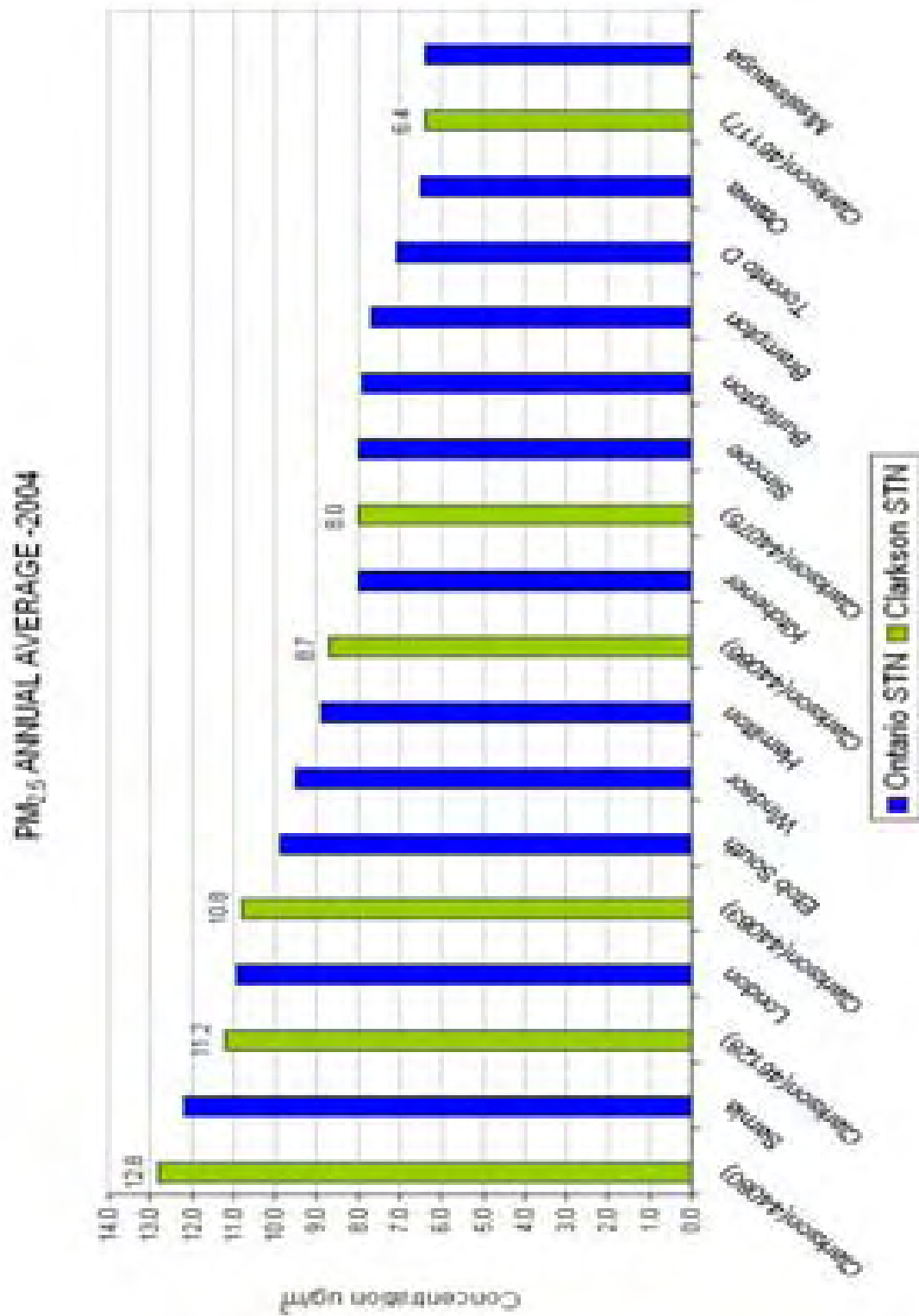
Total Suspended Particulate (TSP) exceeded the 24 hour Ministry AAQC of 120 µg/m<sup>3</sup> on only four occasions over the entire study period and three of the four exceedances were related to smog events. Annual average of TSP were below the MOE AAQC of 60 µg/m<sup>3</sup> at all three stations at which the parameter was measured.

**Figure 5-1****Figure 5-2****Clarkson: PM2.5 Statistical Report  
Whole Period 2003- 2005**

	Whole Period Data No: 89 44080-P2.5	Whole Period Data No: 96 44083-P2.5	Whole Period Data No: 71 46128-P2.5	Whole Period Data No: 715 44075-P2.5T	Whole Period Data No: 620 44086-P2.5T	Whole Period Data No: 816 46117-P2.5T
25th Perc	8.0	7.0	8.0	3.7	4.1	2.6
Min	1.0	2.0	3.0	0.2	0.9	0.1
Average	14.0	11.7	11.3	8.4	8.8	6.9
Median	11.0	10.0	10.0	6.4	6.5	4.9
75th Perc	17.0	13.3	13.5	10.5	11.0	8.9
90th Perc	25.4	18.0	17.0	16.8	17.2	14.2
95th Perc	36.0	29.5	20.0	22.3	23.7	18.7
98th Perc	40.7	39.1	25.2	31.8	32.5	27.4
Max	45.0	43.0	43.0	48.6	41.5	46.4

- NOTES:**
- (i) **STATION NOS:** (a) 44075 – QEW West, (b) 44080 – QEW East, (c) 44083 – Ford Dr, (d) 44086 – Residential, (e) 46117 – Ind. East, (f) 46128 – Ind. Centre
  - (ii) Number of valid points used in the analysis is depicted in each “box” graph as “Data No.”

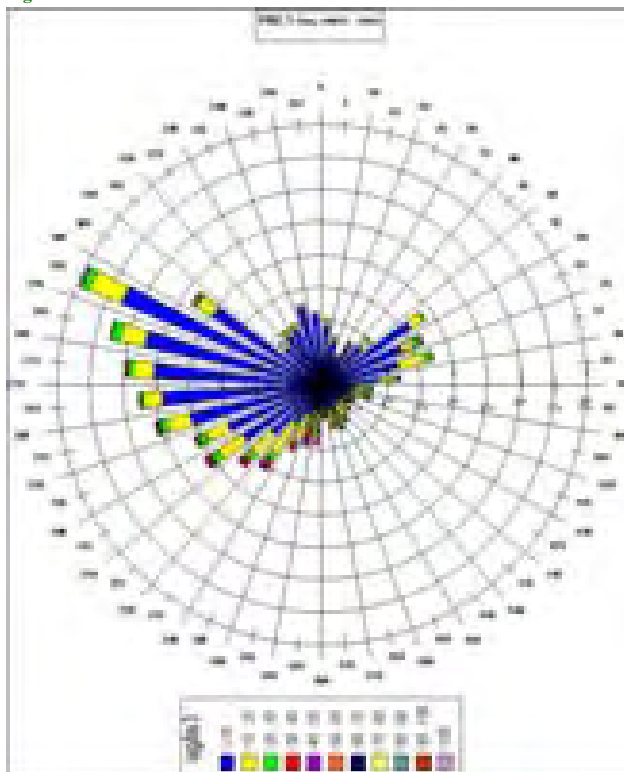
Figure 5-3



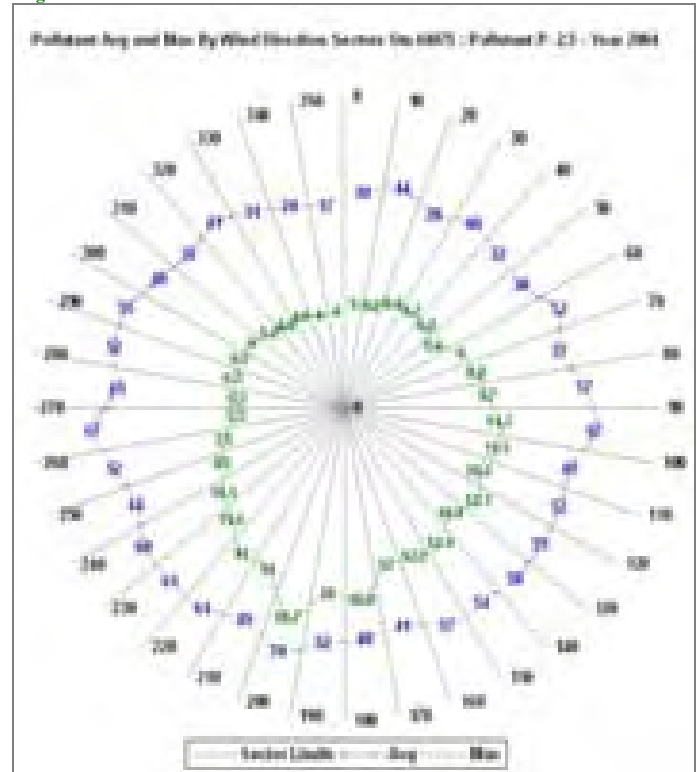
**Figure 5-4 Station Qew West [44075] - Respirable Particulates (PM<sub>2.5</sub>)**



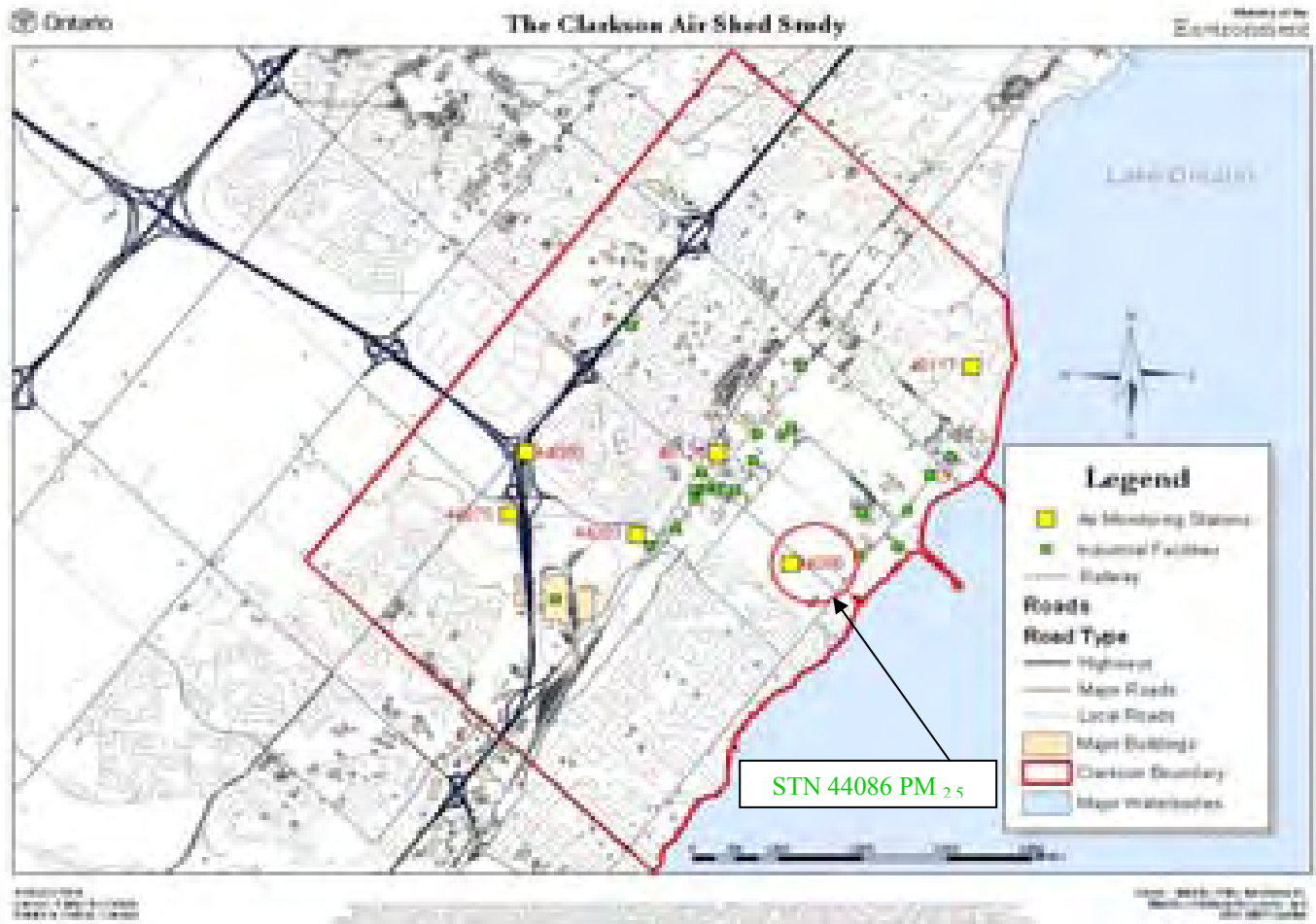
**Figure 5-4A POLLUTION ROSE - STN 44075 PM 2.5**



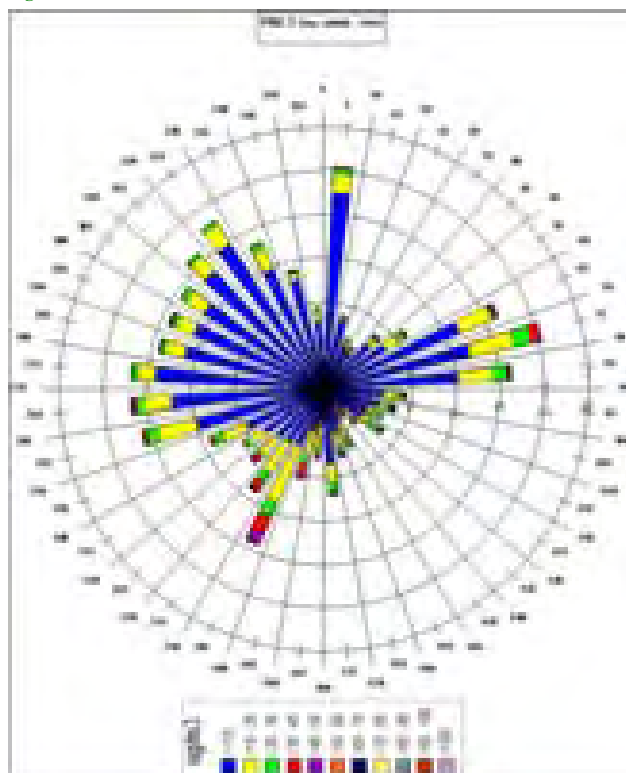
**Figure 5-4B AVG / MAX SECTOR CONCENTRATION - STN 44075 PM 2.5**



**Figure 5-5 Station Residential [44086] -Respirable Particulates (PM<sub>2.5</sub>)**



**Figure 5-5C POLLUTION ROSE-STN44086 PM2.5**



**Figure 5-5D AVG / MAX SECTOR CONCENTRATION-STN44086 PM2.5**

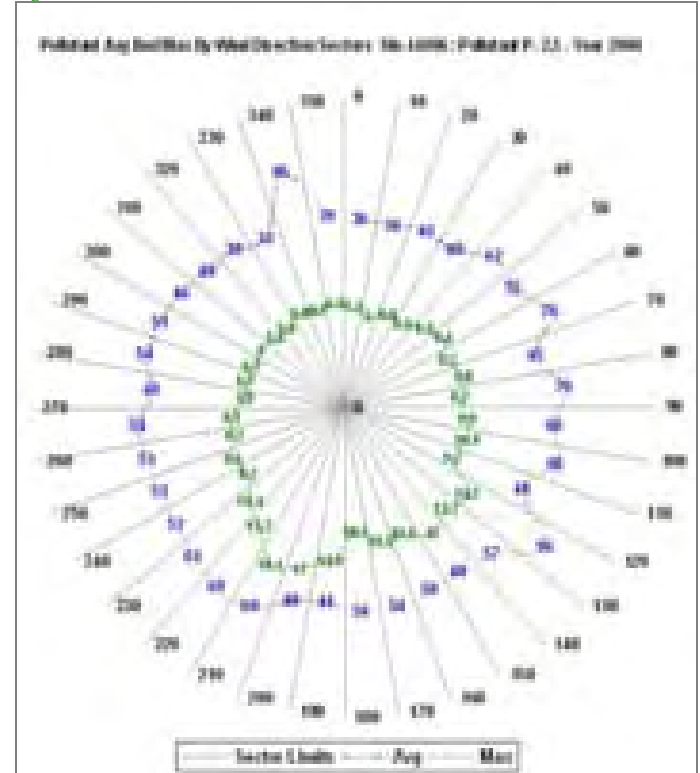


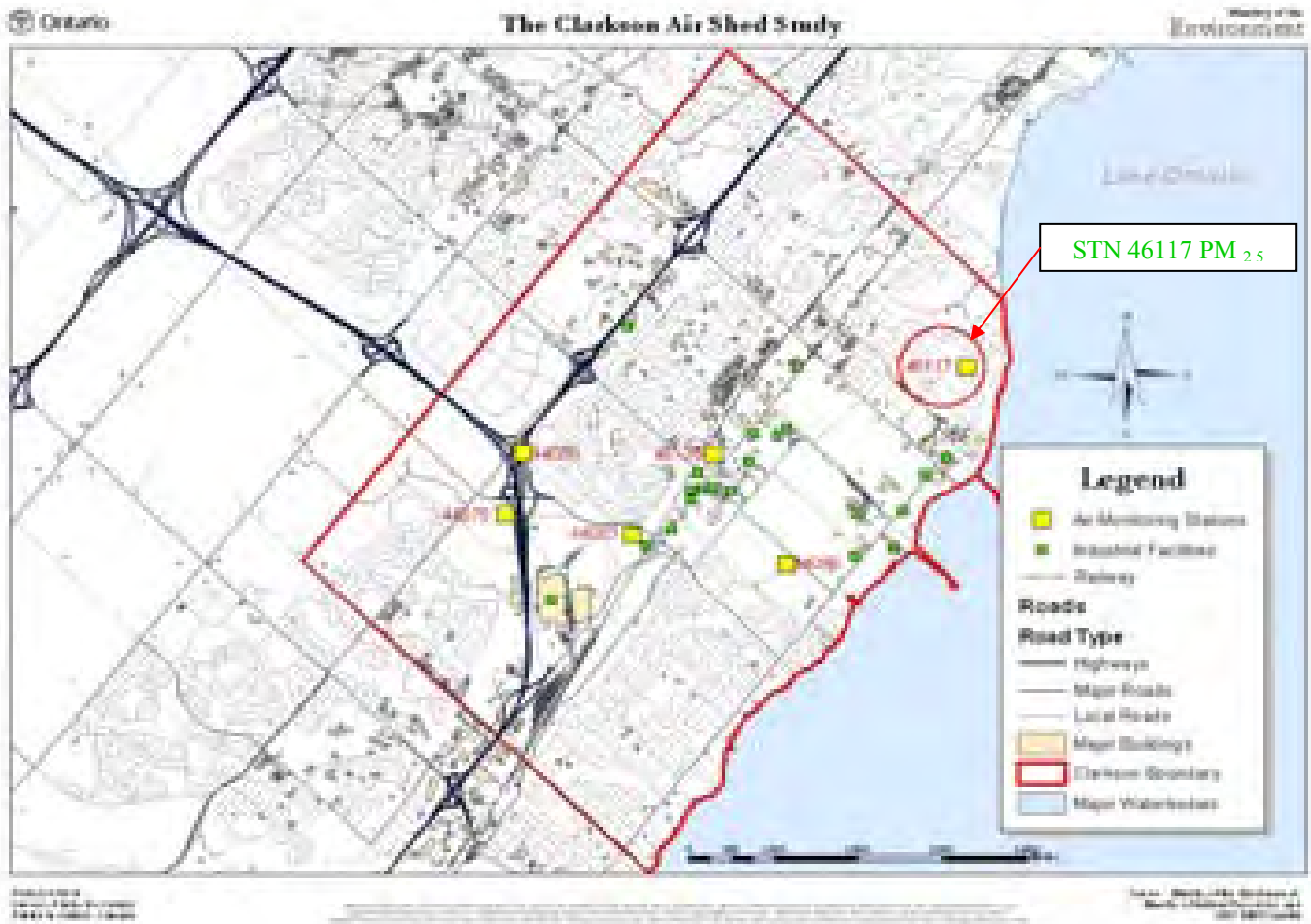
Figure 5-6 Station Ind. East [46117] -Respirable Particulates (PM<sub>2.5</sub>)

FIGURE 5-6E POLLUTION ROSE-STN 46117 PM2.5

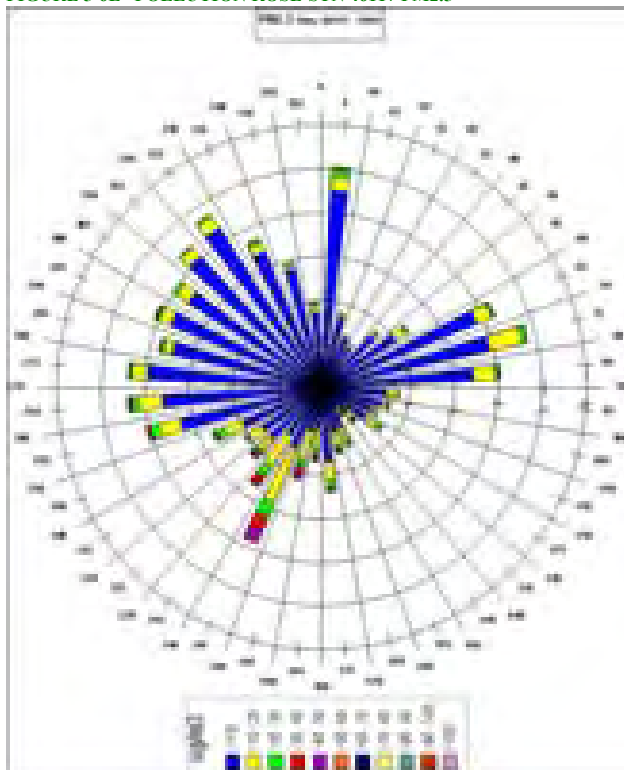


FIGURE 5-6F AVG / MAX SECTOR CONCENTRATION - STN46117 PM2.5

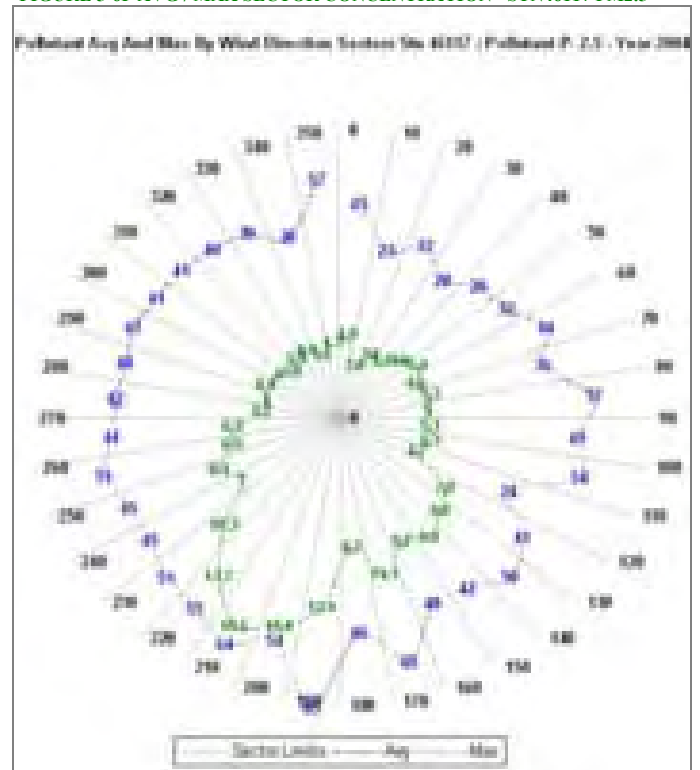


Figure 5-7

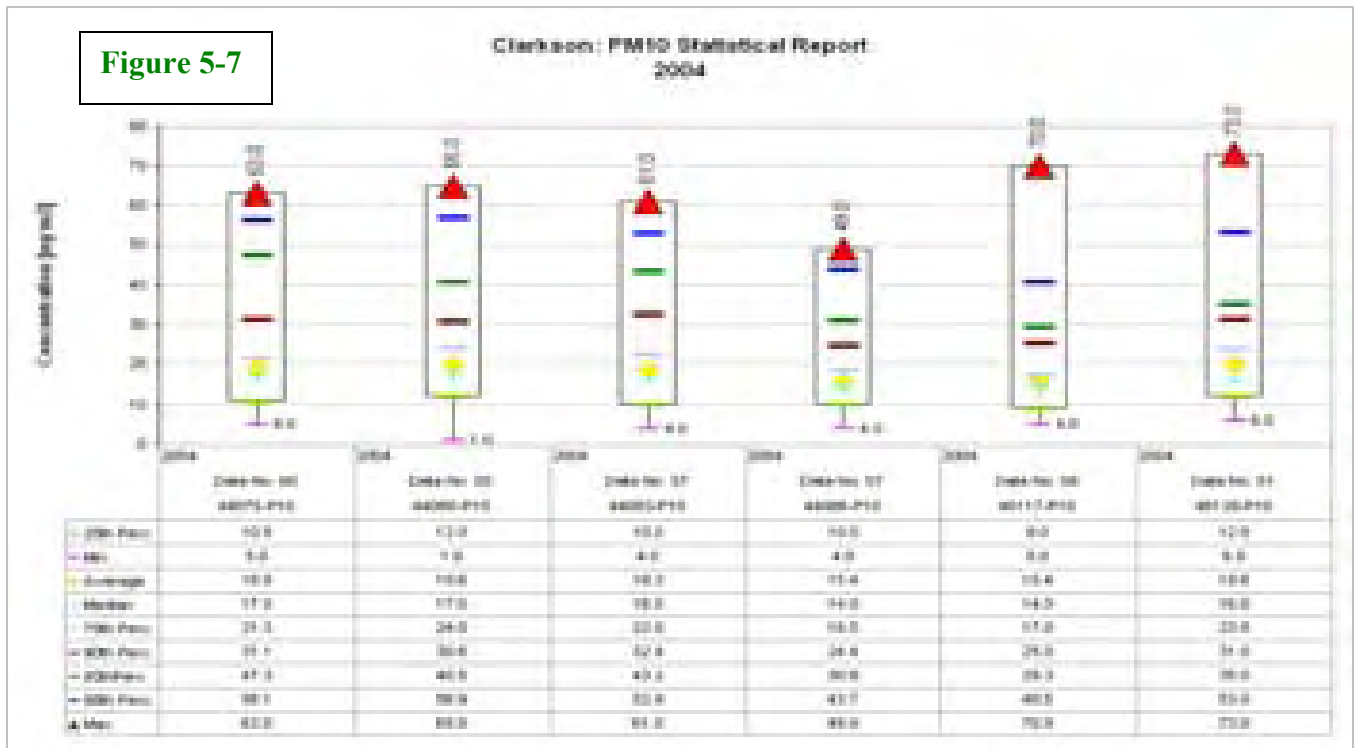
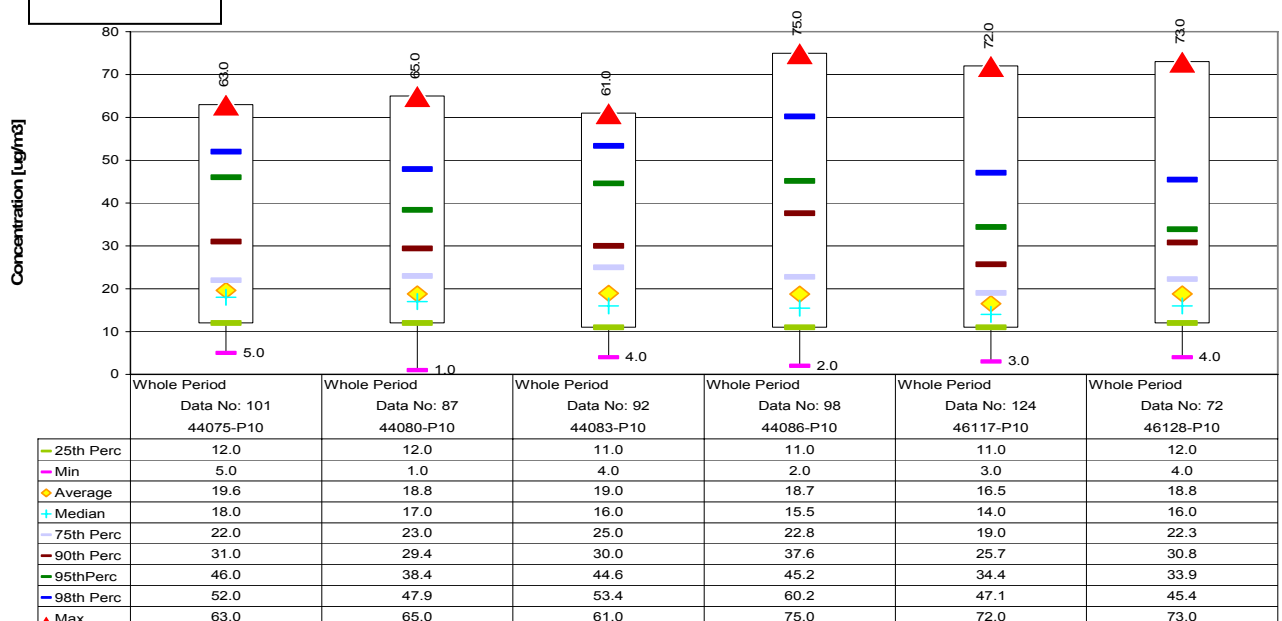


Figure 5-8

**Clarkson: PM10 Statistical Report  
Whole Period 2003 - 2005**



- NOTES:** (i) **STATION NOS:** (a) 44075 – QEW West, (b) 44080 – QEW East, (c) 44083 – Ford Dr, (d) 44086 – Residential, (e) 46117 – Ind. East, (f) 46128 – Ind. Centre
- (ii) Number of valid points used in the analysis is depicted in each “box” graph as “Data No.”



## Section - Six

# Nitrogen Oxides (NO<sub>x</sub>, NO, NO<sub>2</sub>)

## Clarkson Airshed Study: Part II - The Ambient Air Monitoring Program

### 6.0 Summary of Monitoring for NO<sub>x</sub>

Continuous monitoring for nitrogen oxides was carried out at all six CAS monitoring stations. The analyzers or monitors provided continuous “real-time” reporting of Nitric Oxide (NO), Nitrogen Dioxide (NO<sub>2</sub>) and Oxides of Nitrogen (NO<sub>x</sub>).

[Note: Details on the monitoring for NO<sub>x</sub> can be found in Section - Four entitled Pollutant Description and Monitoring Methodology].

### 6.1 Discussion of Monitoring Results

Emissions of NO<sub>x</sub> consist mainly of NO, with some NO<sub>2</sub>. In ambient air, NO converts to NO<sub>2</sub>. NO<sub>2</sub> has adverse effects at much lower concentrations than NO. Recognizing these factors, the Ministry’s AAQC, which are now included in Schedule 3 of O.Reg 419/05, are based on the health effects of NO<sub>2</sub>.

The annual averages for all three parameters for 2004 are included in [Table 6-1](#) and plotted on the CAS study area map in [Figure 6.1](#).

The detailed assessment which follows is for Nitrogen Dioxide (NO<sub>2</sub>) and Nitric Oxides (NO) recognizing that it is generally conceded that NO<sub>x</sub> = NO + NO<sub>2</sub>.

The AAQC for NO<sub>x</sub> is based on NO<sub>2</sub> only. The 24-hour NO<sub>2</sub> AAQC is 100 ppb (200 µg/m<sup>3</sup>)<sup>1</sup>, and the 1-hour NO<sub>2</sub> AAQC is 200 ppb (400 µg/m<sup>3</sup>)<sup>1</sup>.

#### 6.1.1 Nitrogen Dioxide (NO<sub>2</sub>)

[Figure 6-2-A](#) shows the 24 hour 2004 annual average NO<sub>2</sub> values for the CAS study area, which range from a low of 14.1 ppb at Stn Industrial East to a high of 26.0 ppb at Stn QEW East. The NO<sub>2</sub> concentrations at the other four CAS stations ranged from 16 ppb to 17.9 ppb.

1 - Concentration converted from ppb to µg/m<sup>3</sup> using factor of 1.98 based on molecular weight of NO<sub>2</sub> at standard conditions; result rounded off to nearest 100.

**Figure 6-2-B** shows that the average annual NO<sub>2</sub> concentrations recorded in the CAS study area over the whole monitoring period (2003 – 2005) ranged from a low of 14.3 ppb at *Stn Industrial East* to a high of 26.1 ppb at *Stn QEW East*.

Based on the data presented, it is safe to conclude that 2004 is a year that is representative of the entire program with respect to NO<sub>2</sub>.

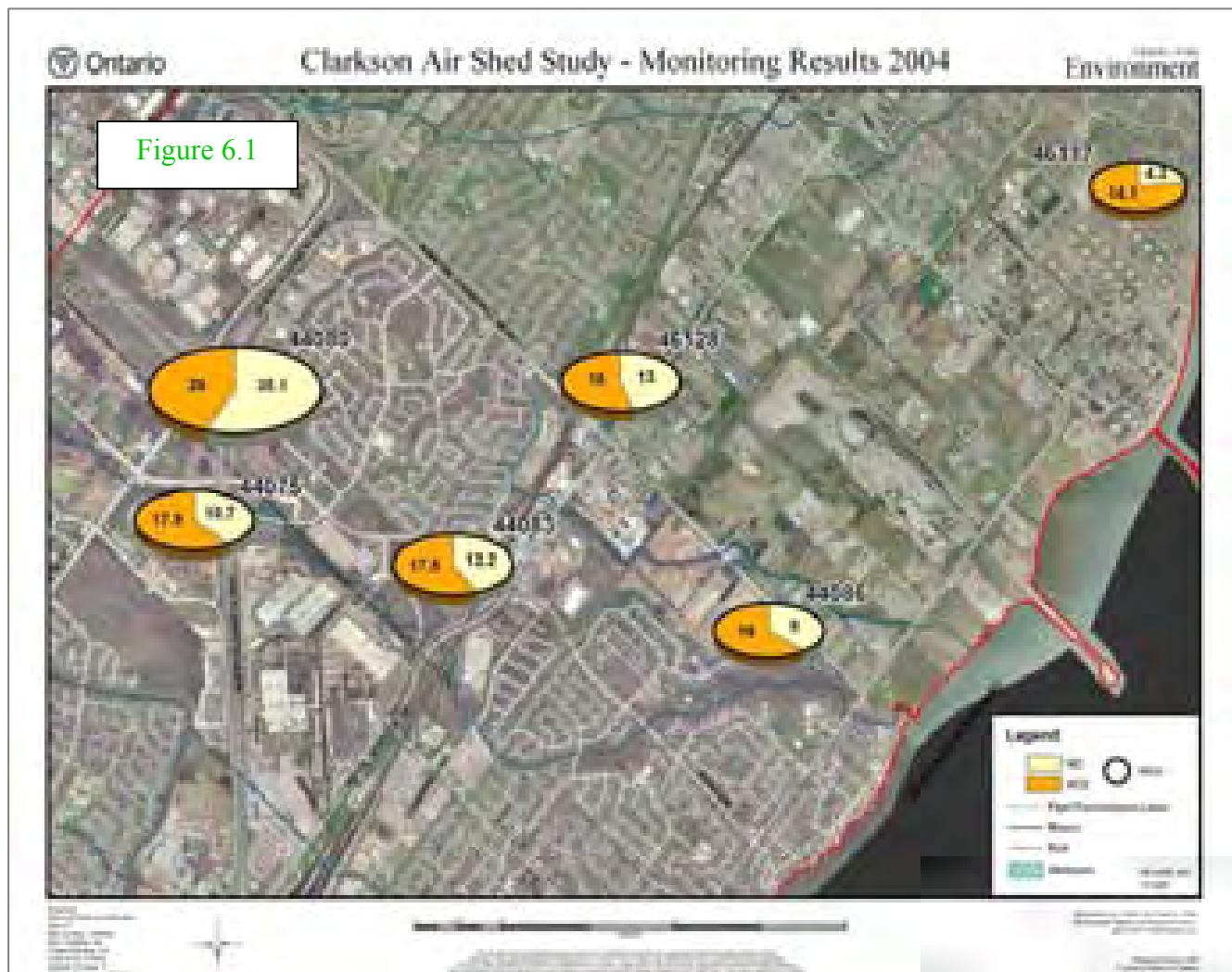
The 24 hour annual average NO<sub>2</sub> concentrations (2004) at the six CAS stations were compared to 2004 NO<sub>2</sub> annual average values at six selected MOE AQI stations in the GTA/Hamilton area.

The AQI sites used included: Toronto (2),

Brampton, Burlington, and Hamilton.

Although the 2004 GTA/Hamilton data set is limited, the comparison (**Figure 6-3**) indicated that the CAS stations reflect similar annual average NO<sub>2</sub> values. The annual average NO<sub>2</sub> concentration of 26.0 ppb at CAS *Stn QEW East* is almost identical to the highest level of 26.1 ppb found in the Ontario (AQI station at Etobicoke South).

As noted in Section 5.1.1 of this report with respect to PM<sub>2.5</sub> the comparison between CAS station NO<sub>2</sub> data and AQI NO<sub>2</sub> data was made recognizing that AQI stations are located for the purpose of assessing general air quality, whereas



CAS monitoring locations were chosen to focus on specific sources. The comparison has been made to simply give context to the CAS data.

In 2004, the highest 24 hour NO<sub>2</sub> concentration of 59.9 ppb (see **Figure 6-2-A**) was recorded at *Stn QEW East* and the highest 1 hour concentration of 134 ppb (see **Table 6-2**) was recorded at *Stn Industrial East*. Neither of these values exceeds the Ministry's NO<sub>2</sub> 24 hour AAQC of 100 ppb or the 1 hour AAQC of 200 ppb.

**Table 6-2**

Maximum 1-hour NO <sub>2</sub> Concentration (ppb)						
YEAR	QEW West	QEW East	Ford Dr	Res.	Ind. East	Ind. Centre
2003	76	129	75	73	74	50
2004	119	108	67	80	134	75
2005	131	83	98	72	53	70

### 6.1.2 Nitric Oxide (NO)

Monitoring stations located closer to significant emission sources such as major highways and industrial facilities will record higher NO values. Over a number of hours, NO will oxidize and convert to NO<sub>2</sub>, which is more harmful to human health than NO.

**Figure 6-4-A** shows that the 2004 24 hour NO annual average values range from a low of 4.3 ppb at *Stn Industrial East* to a high of 35.1 ppb at *Stn QEW East*. The range of NO concentrations at the other four stations was from 10.7 ppb to 13.0 ppb.

The value of 35.1 ppb for *Stn QEW East* was 170% higher than the next highest Clarkson station. The close proximity of the station to the QEW highway and prominent wind directions (west northwest to southwest) contributed to these results.

**Figure 6-4-B** shows that the 24-hr annual average NO concentration recorded in the CAS study area over the whole monitoring period ranged from a low of 6.5 ppb at *Stn Industrial East* to a high of 36.5 ppb at *Stn QEW East*. Since NO annual averages for 2004 are in the

same range, 2004 can be considered representative of the entire monitoring period.

In 2004, as depicted in **Figure 6-4-A**, the highest 24 hour NO concentration was 137.6 ppb and the highest one-hour concentration as shown in **Table 6-3** was 460 ppb. Both values were recorded at *Stn QEW East*.

**Table 6-3**

Maximum 1-hour NO Concentration (ppb)						
YEAR	QEW West	QEW East	Ford Dr	Res.	Ind. East	Ind. Centre
2003	273	380	340	402	241	379
2004	241	460	339	368	200	429
2005	268	405	303	311	261	321

From **Figure 6-4-B**, the highest 24 hour NO concentration identified during the whole monitoring period was 155.3 ppb and the highest one-hour concentration was 460 ppb (**Table 6-3**). Both these values were recorded at *Stn QEW East*.

Since there are no specific Ministry criteria for NO the emphasis of our impact assessment was put on a wind sector, source-related evaluation as discussed in Section 6.1.2.1 and an evaluation of transportation sector emissions as discussed in Section 6.2.

#### 6.1.2.1 Wind Sector Data Assessment For NO

##### (a) The Approach:

Data from all six NO<sub>x</sub> analyzers were correlated with hourly meteorological data. As in the case of the PM<sub>2.5</sub> wind sector data assessment, the 360 degree compass was divided into 10 degree *wind sectors* in order to determine the most common wind directions that correlated with the highest pollutant concentrations.

The wind sector assessment of NO<sub>x</sub> in the CAS study area focuses on NO hourly concentrations since NO is a key factor in NO<sub>2</sub> formation in the atmosphere and a key contributor to total NO<sub>x</sub> concentrations, due to its significant presence in

vehicular emissions. The trend or profile of NO<sub>x</sub> emissions monitored throughout the CAS air monitoring program was similar to NO, thus confirming that such an approach is valid.

Wind rose and pollution rose data, as well as maximum and average sector hourly NO concentrations were used in the wind sector assessment. This approach helped in defining the role that meteorological conditions played in affecting NO concentrations within the CAS study area and the role that these conditions play in the contribution of NO to the area from long-range transport and other sources external to the area.

As noted in Section – Five, the *maximum sector concentration* is the highest hourly value recorded in each particular wind sector and the *average sector concentration* is the average value calculated for each wind sector.

The results of the NO wind sector data assessments which follow, focus on 2004 since it was the only complete year of NO<sub>x</sub> monitoring conducted as part of the CAS ambient air monitoring program.

## **(b) The Results:**

### ***Stn QEW West***

At *Stn QEW West*, predominant winds were mainly from the southwest - west northwest in sectors 210 to 310 degrees [see **Figure 6-5-A** and **Figure 6-5-B**]. These wind directions did not correlate with either the peak annual average sector or the maximum sector NO concentrations.

Wind sectors ranging from 20 to 50 degrees and 150 to 170 degrees yielded the highest average sector NO concentrations of 22.1 to 23.5 ppb and maximum values of 235 to 241 ppb respectively.

These high values appear to have originated from vehicular traffic on the QEW while the lowest NO average values of 3.3 to 3.8 ppb and the lowest maximum value of 65 ppb came from

the 230 to 270 degree and 190 to 200 degree wind sectors respectively and could very well represent background residential values.

### ***Stn QEW East***

At *Stn QEW East*, predominant winds were identical to *Stn QEW West*, originating from mainly southwest - west northwest in sectors 210 to 310 degrees [see **Figure 6-6-A** and **Figure 6-6-B**]. These wind directions did correlate with both the peak average sector NO concentration and the maximum sector NO concentration.

The highest average sector NO concentrations of 66.6 to 69.4 ppb and the highest maximum value of 459 to 460 ppb both occurred between wind sectors 280 and 300 degrees. This is clearly indicative of input from the QEW.

Wind sectors ranging from 50 degrees to 70 degrees contributed to the lowest maximum and lowest average sector concentrations which were 42 ppb and 3.2 to 4.1 ppb respectively. These low values were likely attributed to the nearby residential community.

### ***Stn Ford Dr***

At *Stn Ford Dr*, predominant winds were also mainly from the southwest - west northwest in sectors 210 to 310 degrees [see **Figure 6-7-A** and **Figure 6-7-B**]. These wind directions did correlate with the peak average sector concentration but not quite as closely with maximum sector NO concentrations.

Wind sectors ranging from 280 to 300 degrees and 220 to 230 degrees yielded the highest average sector NO concentrations of 17.1 to 21.3 ppb and the highest maximum NO value of 339 ppb respectively.

It is important to note that there were other maximum sector values of 326 ppb and 333 ppb which did fall in the predominant wind sector range of 210 to 310 degrees.

Once again high values appear to have a distinct connection to vehicular traffic on the QEW but there could also be input from a nearby industrial facility located upwind of the monitoring station with respect to the predominant wind direction.

Low NO average sector values in the range of 5.9 to 9.9 ppb are prevalent in three sector ranges: (i) 100 to 150 degrees, (ii) 210 degrees to 280 degrees, and (iii) 300 degrees to 0 degrees. For the most part these sector ranges point to background residential sources.

The lowest maximum sector concentrations are in the range of 36 to 44 ppb and originate from sectors 100 to 150 degrees. These sectors reflect sources in the southwest end of the nearby industrial park and residential areas in southeast.

### *Stn Residential*

At *Stn Residential*, predominant winds were mainly from west southwest - northwest in sectors 250 to 340 degrees [see **Figure 6-8-A** and **Figure 6-8-B**]. These wind directions do correlate with the peak annual sector average of 15.6 ppb but not with the maximum sector concentration.

In fact, the peak average sector concentration (15.6 ppb) occurs not only in wind sector 330 degrees to 340 degrees but also in sector 90 degrees to 100 degrees. Both of these relate well to industrial sources in the north northwest and in the east to east northeast.

The maximum sector NO concentrations of 355 and 368 ppb occurred in wind sectors 70 to 90 degrees, and also may be a result of input from the industry located to east-northeast of the station.

The lowest average and maximum NO concentrations (5.2 to 5.8 ppb and 64 ppb, respectively), originate from wind sectors 200 to 260 and likely reflect residential background.

### *Stn Industrial East*

At *Stn Industrial East* predominant winds were mainly from southwest - north northwest in sectors 250 to 350 degrees [see **Figure 6-9-A** and **Figure 6-9-B**]. These wind directions do not line up with the peak average sector NO concentrations or the maximum sector concentrations.

The wind sector from 140 to 150 degrees yielded the highest average sector NO concentration of 13.3 ppb. The highest maximum sector value of 200 ppb occurred in wind sector 70 to 80 degrees.

These high values appear to have originated from industrial sources to the south southeast and from external/long range sources.

The lowest NO values of 2.3 ppb (average) and 24.0 ppb (maximum) came from the 10 to 20 degree wind sector and likely represent background residential values.

### *Stn Industrial Centre*

As in the case of *Stn Industrial East*, predominant winds affecting *Stn Industrial Centre* were mainly from the southwest - north northwest in sectors 250 to 350 degrees [see **Figure 6-10-A** and **Figure 6-10-B**]. These wind directions did not correlate with either the peak annual average sector NO concentration or maximum sector concentration.

Wind sector 20 to 30 degrees had the peak average sector concentration of 19.8 ppb but there are also other high values in wind sectors 350 to 20 degrees (17.0 to 18.0 ppb). These elevated average sector values appear to come from both residential and industrial sources in the immediate vicinity of *Industrial Centre* to the northeast around to northwest. A high average value of 17.5 ppb also occurred in wind sector 40 to 50.

This somewhat 'scattered' pattern is also true for the maximum sector NO concentrations which peak at 429 ppb in wind sector 70 to 80 degrees but have elevated values in sector 10 to 20 degrees (314 ppb) and sectors 260 to 290 degrees (324 - 361 ppb). As in the case of the average values, these too appear to relate to nearby industrial and residential sources.

With one minor exception, the lowest average sector NO values in the range of 9.2 to 9.5 ppb and the low maximum value of 91 ppb originate from wind sectors 220 to 260 likely reflect residential background.

### 6.1.3 Nitrogen Oxides (NO<sub>x</sub>)

NO<sub>x</sub> is a combination of both NO and NO<sub>2</sub>. The maximum one-hour NO<sub>x</sub> values are listed in Table 6-4. Figure 6-11A and Figure 6-11-B shows the 24 hour average NO<sub>x</sub> concentrations for 2004 and 2003 - 2005.

Table 6-4

Maximum 1-hour NO <sub>x</sub> Concentration (ppb)						
YEAR	QEW West	QEW East	Ford Dr	Res.	Ind. East	Ind. Centre
2003	318	426	396	438	308	421
2004	277	564	405	447	243	488
2005	312	485	369	367	292	357

The NO<sub>x</sub> data were not analyzed in any great detail for two reasons: (i) it is NO<sub>2</sub> for which we have a health-based standard; and (ii) NO is more of a concern in terms of its ability to convert to NO<sub>2</sub> and its presence as a key component of vehicular emissions.

## 6.2 Transportation Sector Assessment(QEW)

Figure 6-12 illustrates the average concentration for each hourly value of NO in ppb calculated from NO<sub>x</sub> measurements taken over the entire monitoring period from June 2003 to March 2005 at Stn QEW East (located adjacent to the QEW).

The transportation sector assessment has been based on this data set and includes consideration of appropriate wind direction and wind speed data.

Looking at the complete monitoring year of 2004, the annual average concentration for NO at Stn QEW East was 35.1 ppb and the annual average for the same station during the entire monitoring period was similar at 36.5 ppb.

In Figure 6-12 it should be pointed out that the CAS air monitoring program ended on March 31/05 and as such, the data set for 2005 is representative solely of winter months (January, February, March). It is evident that the average hourly NO concentrations are higher during these months.

In Figure 6-12 it is clear that the highest hourly concentration for each of the three years occurred at 7:00 am. In fact, this concentration represents the average concentration between 6:00 am and 7:00 am EST. For 2003 this concentration was 70.0 ppb, for 2004 the concentration was 64.0 ppb and, for 2005 the concentration was 73.6 ppb.

Morning peak traffic rush hour period occurs between 5:00 am and 10:00 am. The average NO concentration over the morning rush hour period was 55.5 ppb in 2003, 53.5 ppb in 2004, and 60.1 ppb in 2005. The overall average was 56.4 ppb. The morning rush hour period average concentration at Stn QEW East was 54.4% higher than the average concentration of 36.5 ppb, which was obtained for the whole CAS air monitoring period at that station.

The peak afternoon rush hour period occurs between 4:00 pm and 7:00 pm. The average Nitric Oxide (NO) concentrations over this period are approximately 50 % lower than the morning rush hour period. Several factors contribute to this: (i) wind speeds are usually greater throughout the day compared to very light winds which occur during the morning rush hour period; (ii) the predominant wind directions are those with generally stronger winds which



would contribute to the percentage of time the station is downwind of the QEW; and (iii) solar radiation and air mixing would be more of a factor in the late morning and into the afternoon rush hour period, which would lead to lower concentrations.

An additional review of specific wind directions and wind speeds along with consideration of upwind and downwind sources was carried out to fully assess the traffic contributions.

Both *Stn QEW West* and *Stn QEW East* were used to assess the upwind / downwind contributions of the QEW as depicted in **Figure 6-13**. Hourly NO data was screened using minimum wind speed and a specific wind sector.

To address the issue of minimum wind speed requirements and how they reflect interpretation of the NO data set, wind speeds greater than 3.6 km/hr limits were used so that a clearly identifiable wind direction would be available.

To accommodate the appropriate wind direction, a specific wind sector of 190 to 215 degrees was selected so that *Stn QEW West* would be directly upwind of the QEW and *Stn QEW East* would be directly downwind.

The review was carried out for both morning and afternoon rush hour periods.

The results of the review were as follows:

- (i) during the morning rush hour period, the NO concentration at upwind *Stn QEW West* was 11.0 ppb as compared to 58.6 ppb for the downwind *Stn QEW East*;
- (ii) consequently the NO impact from the traffic during morning rush hour was 47.7 ppb;
- (iii) during the afternoon rush hour period the NO concentration was 5.0 ppb for the upwind *Stn QEW West* as compared to 40.6 ppb for the downwind *Stn QEW East*;
- (iv) consequently, the NO impact from the traffic during the afternoon rush hour was 35 ppb;

- (v) overall, the morning rush hour concentration of NO was 36.3% higher in the morning than in the afternoon

**Figure 6-13 Evaluation of QEW Rush Hour NO Impact**



The findings support the information shown in **Figure 6-12**. A measurable difference exists between NO emissions from morning rush hour traffic and emissions from afternoon rush hour.

### **6.2.1 Modeling of NO (Nitric Oxide) Concentrations Downwind Of QEW**

To further evaluate the transportation sector NO impacts relative to the QEW, modeling was carried out using the AERMOD dispersion model. The percent reduction in NO concentration with increasing distance from the QEW was calculated.

A one-year meteorological data set was used to model the section of the QEW in the CAS study area. The modeling was done using unit NO emissions [ie. 1 gram per second or 1 g/sec] and yielded an average NO concentration of 47.7 ppb

for each of the 12 months when compared to concentrations near the edge of the roadway (within 20 m). The model also predicted monthly average concentrations to decrease with increasing distance from the highway as shown in Table 6-5.

Table 6-5

Distance From the Highway (QEW) – Percent Reduction in NO Concentration		
	% Reduction	Concentration
100 metres	40-45 %	28.6 ppb to 26.2 ppb
200 metres	65-70 %	16.7 ppb to 14.3 ppb
300 metres	75-80 %	11.9 ppb to 9.5 ppb

Note that in the above table, the predicted percentage reductions only represent the impact of emissions from the QEW. Measured concentrations would include all sources in combination. Figure 6-14 illustrates the percentage reduction in relation to the proximity of residences to the QEW (within 200 to 300 metres).

### 6.3 Summary of Results - Observations

During the period of the entire CAS ambient air monitoring program there were no exceedances of the Ministry NO<sub>2</sub> 24 hr AAQC of 100 ppb or the 1 hr NO<sub>2</sub> AAQC of 200 ppb.

In 2004, NO<sub>2</sub> annual average concentrations at Stn QEW East were found to be 45.3% higher than the next highest CAS station. During the same period, NO<sub>x</sub> and NO concentrations at the same monitoring station were 111.0 % higher and 168 % higher respectively, than at the next highest CAS station. Vehicular traffic on the QEW was responsible for these elevated values

As a means of putting the CAS 2004 NO<sub>2</sub> annual average concentrations into context, NO<sub>2</sub> 24 hour annual concentrations for six AQI stations in the Greater Toronto Area (GTA) and Hamilton area were compared with CAS monitoring data. In this comparison, Stn QEW East was found to be among the highest of the stations compared.

As noted in Section - Five, the comparison is not strictly an equitable one since AQI stations are located in order to assess general air quality

Figure 6-14 Change in NO Concentration With Distance From QEW



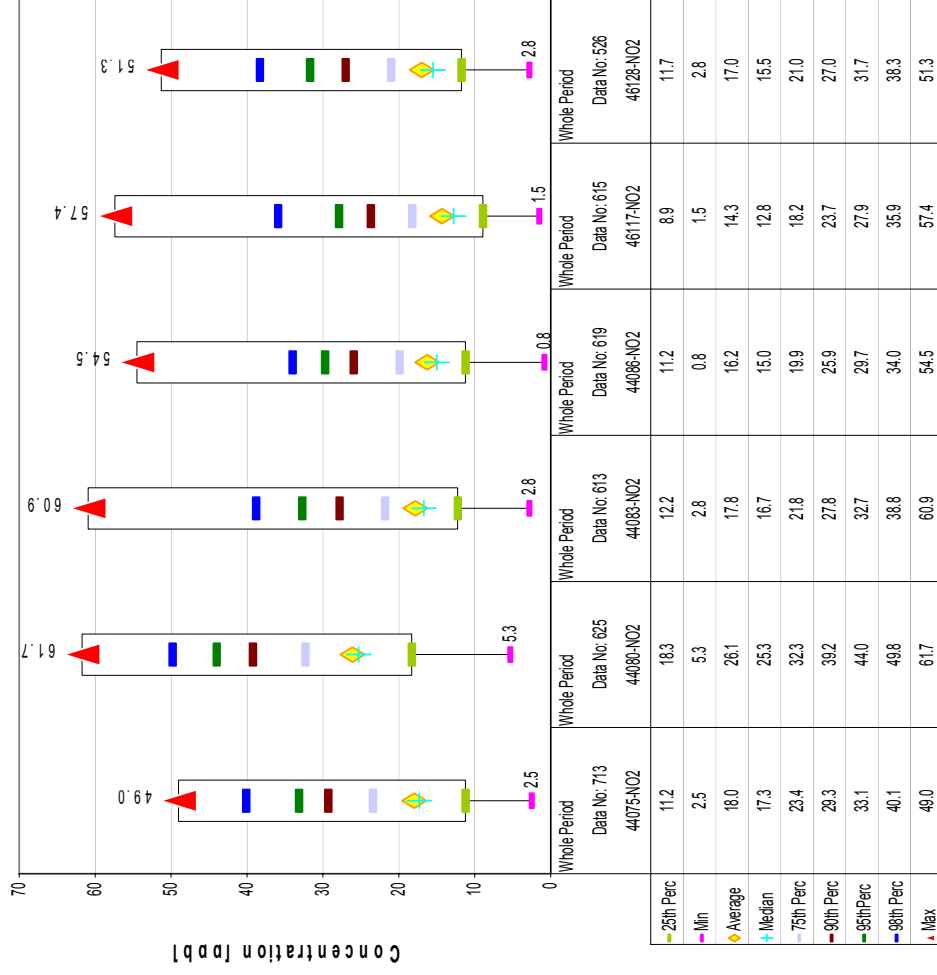
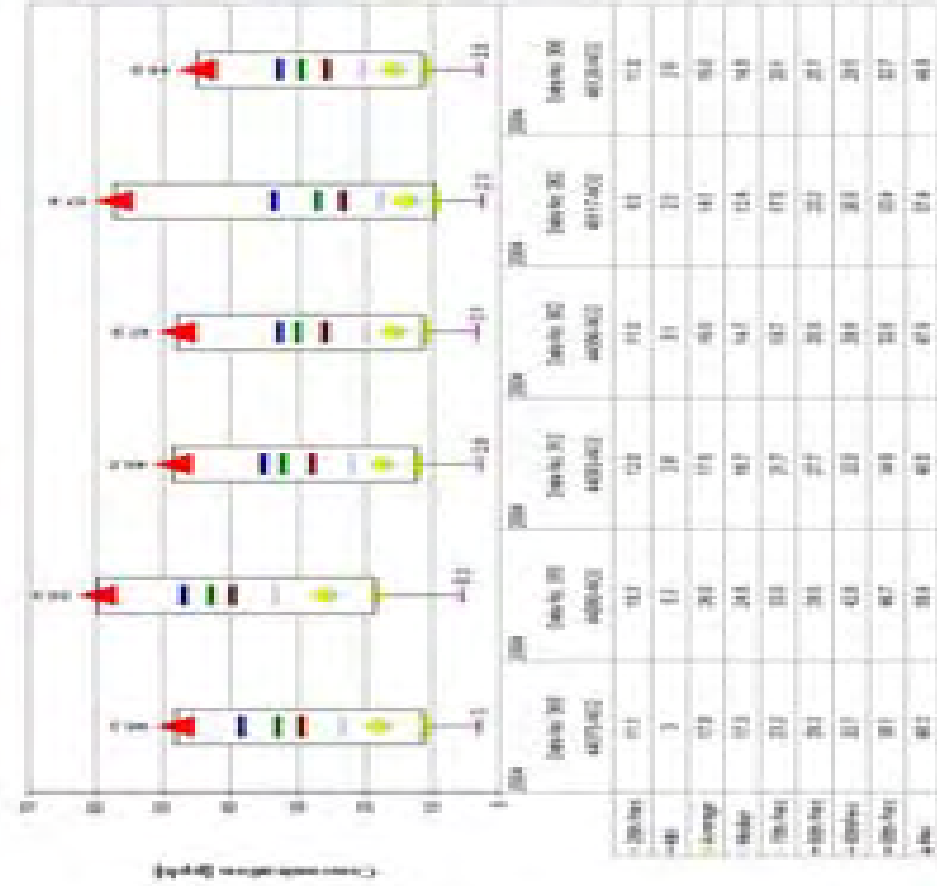
whereas CAS monitoring locations were more focused on specific sources such as the QEW. This approach is only intended to give some context to the CAS NO<sub>2</sub> concentrations.

Morning rush hour NO concentrations measured adjacent to the QEW were found to be measurably higher (about 36%) than the afternoon rush hour. The highest hourly value was found to have occurred between 6:00 am to 7:00 am in each of the three years (or portions thereof) over which the CAS monitoring stations were in operation.

NO wind sector data was used to assess industrial sources. The wind sector evaluation indicated that NO background concentrations in nearby residential areas were in the range of 3.2 to 9.5 ppb (annual average). This wind sector approach as used in the CAS ambient air monitoring program will be used in conjunction with modeling data during Part III of the

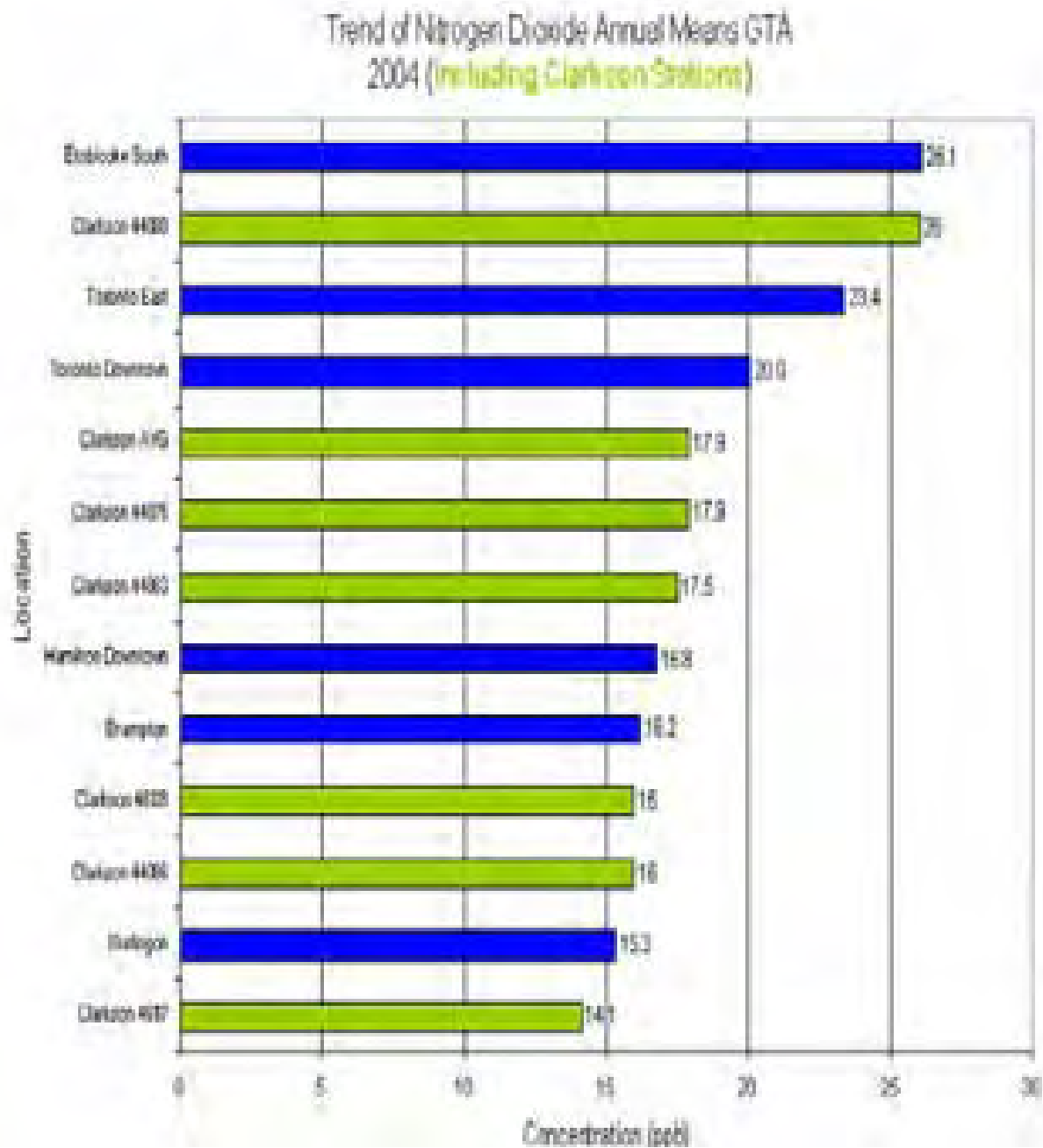


Clarkson Airshed Study to further assess specific industrial, traffic and residential / background contributions relative to NO/NOx.



NOTES: (i) STATION NOS: (a) 44075 – QEW West, (b) 44080 – QEW East, (c) 44083 – Ford Dr, (d) 44086 – Residential, (e) 46117 – Ind. East, (f) 46128 – Ind. Centre  
(ii) Number of valid points used in the analysis is depicted in each “box” graph as “Data No.”

Figure 6-3

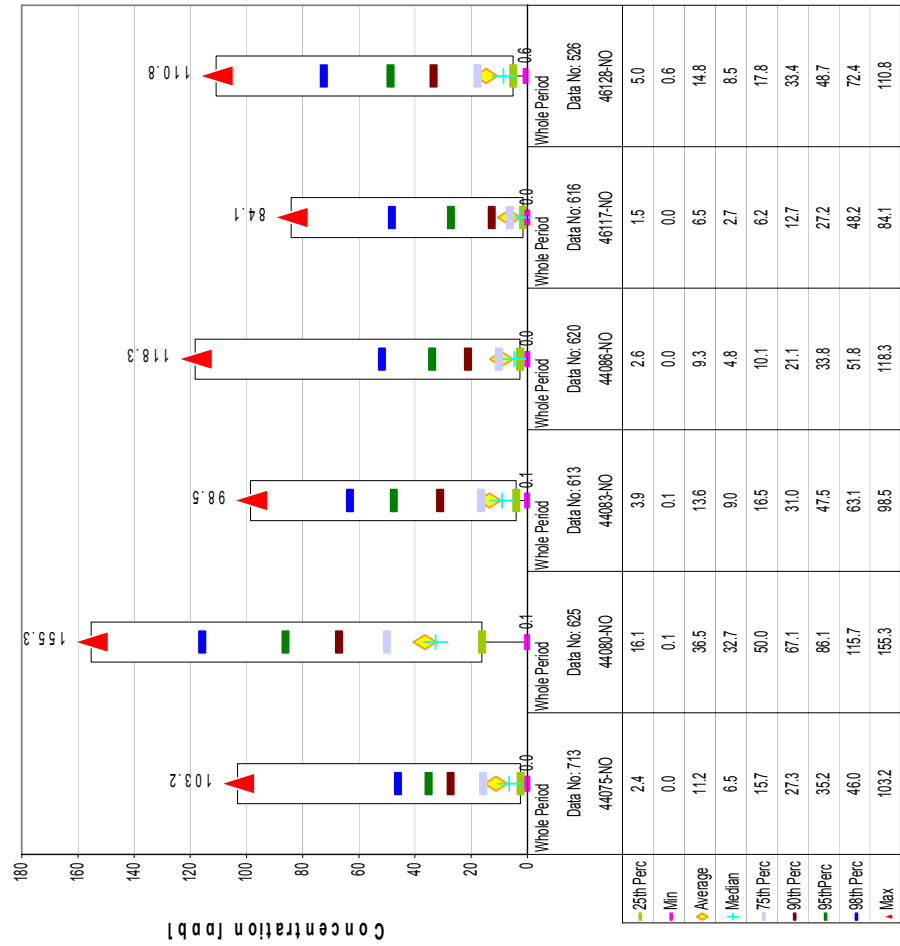


A

Figure 6-4

B

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Whole Period 2003 to 2005



NOTES: (i) STATION NOS: (a) 44075 – QEW West, (b) 44080 – QEW East, (c) 44083 – Ford Dr, (d) 44086 – Residential, (e) 46117 – Ind. East, (f) 46128 – Ind. Centre  
(ii) Number of valid points used in the analysis is depicted in each “box” graph as “Data No.”

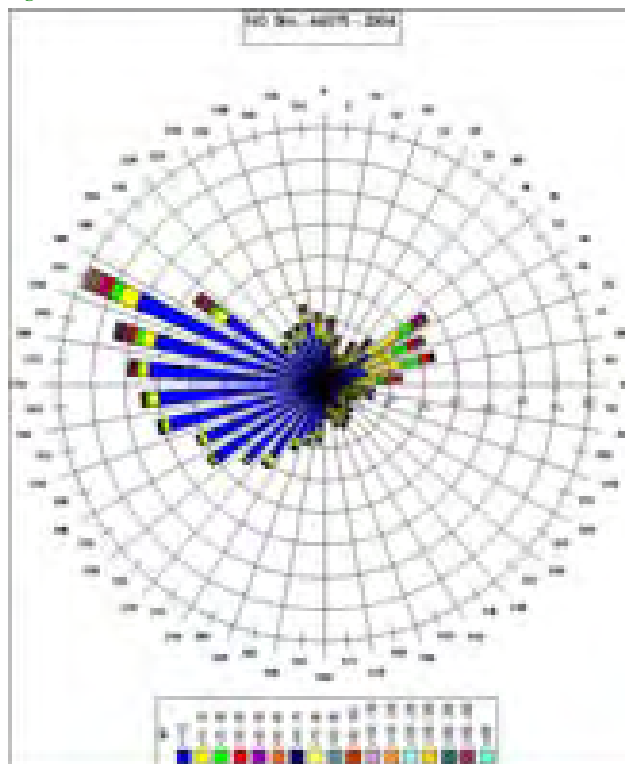
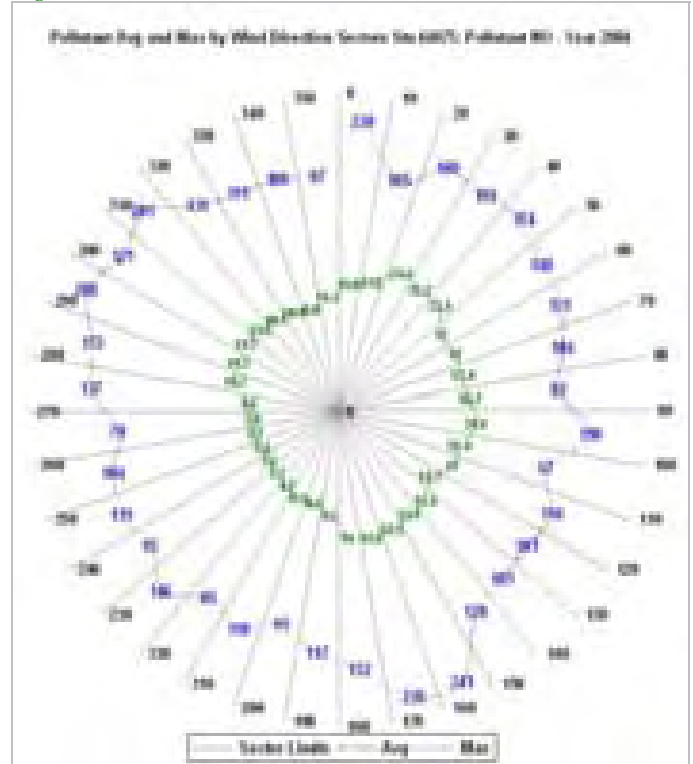
**Figure 6-5 Station Qew West [44075] -Nitric Oxide (NO)****Figure 6-5A POLLUTION ROSE-STN 44075 NO****Figure 6-5B AVG / MAX SECTOR CONCENTRATION STN 44075 NO**

Figure 6-6 Station Qew East [44080]-Nitric Oxide (NO)



FIGURE 6-6A - POLLUTION ROSE-STN 44080 NO

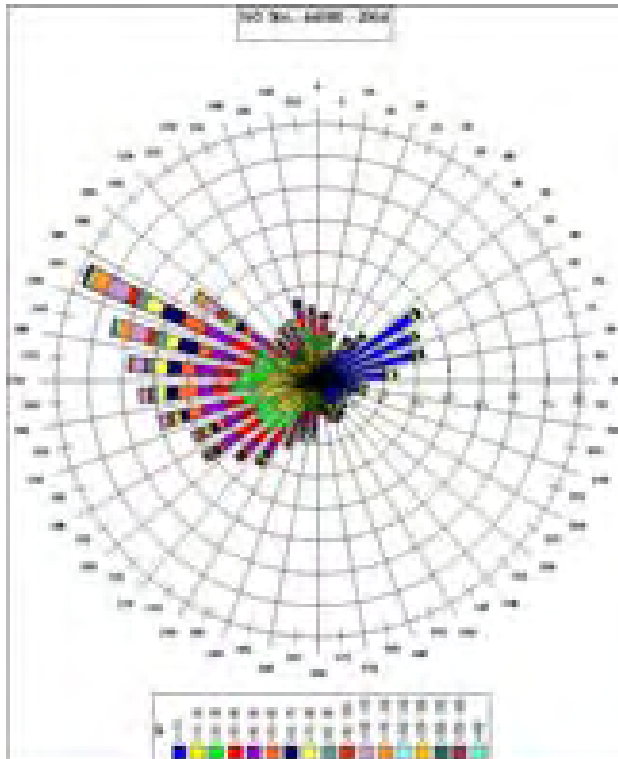
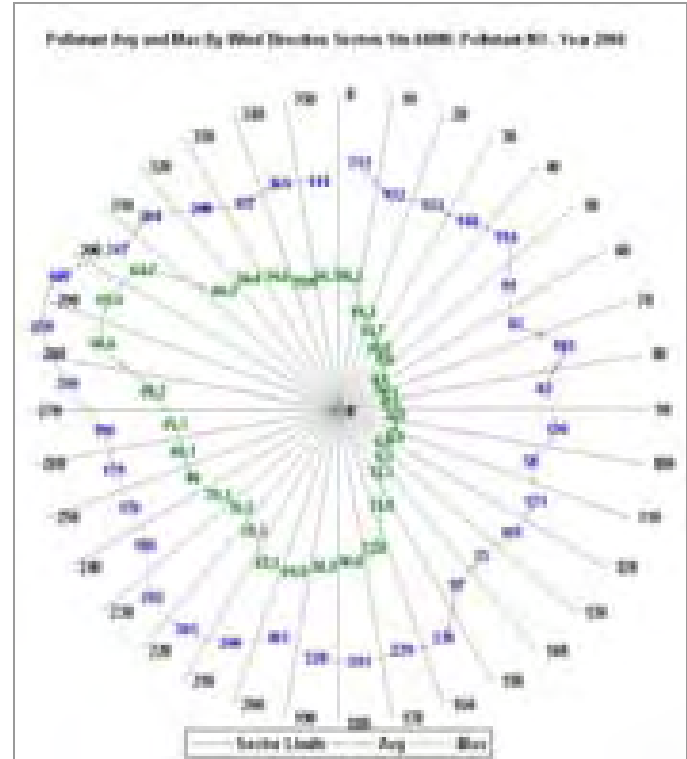
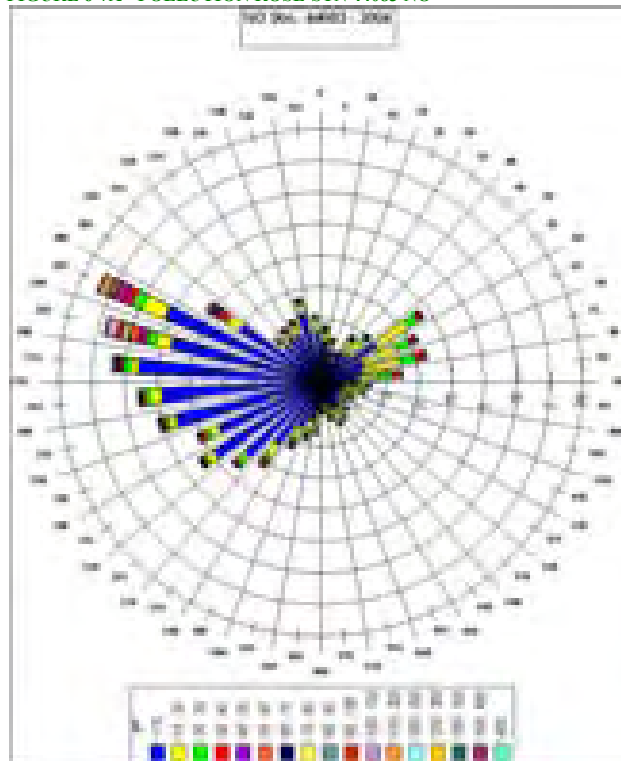
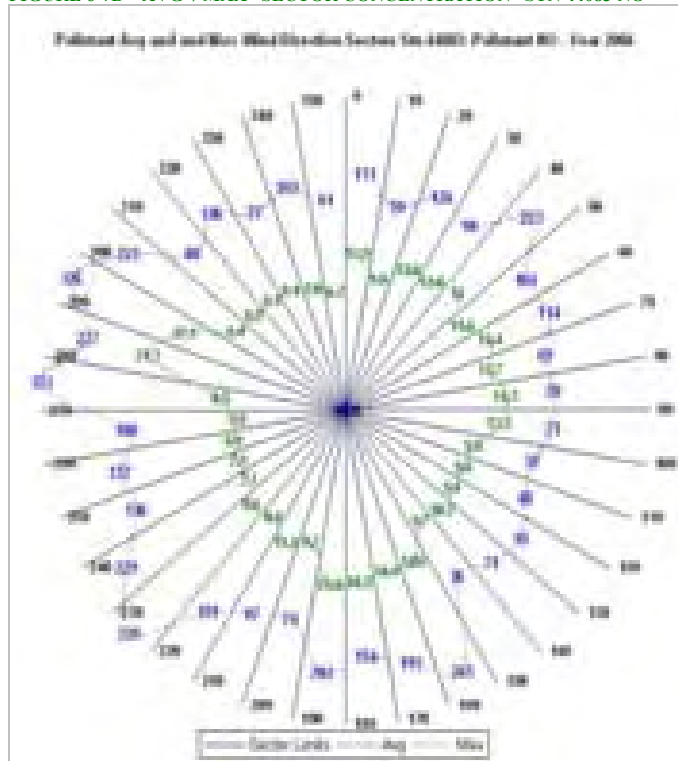


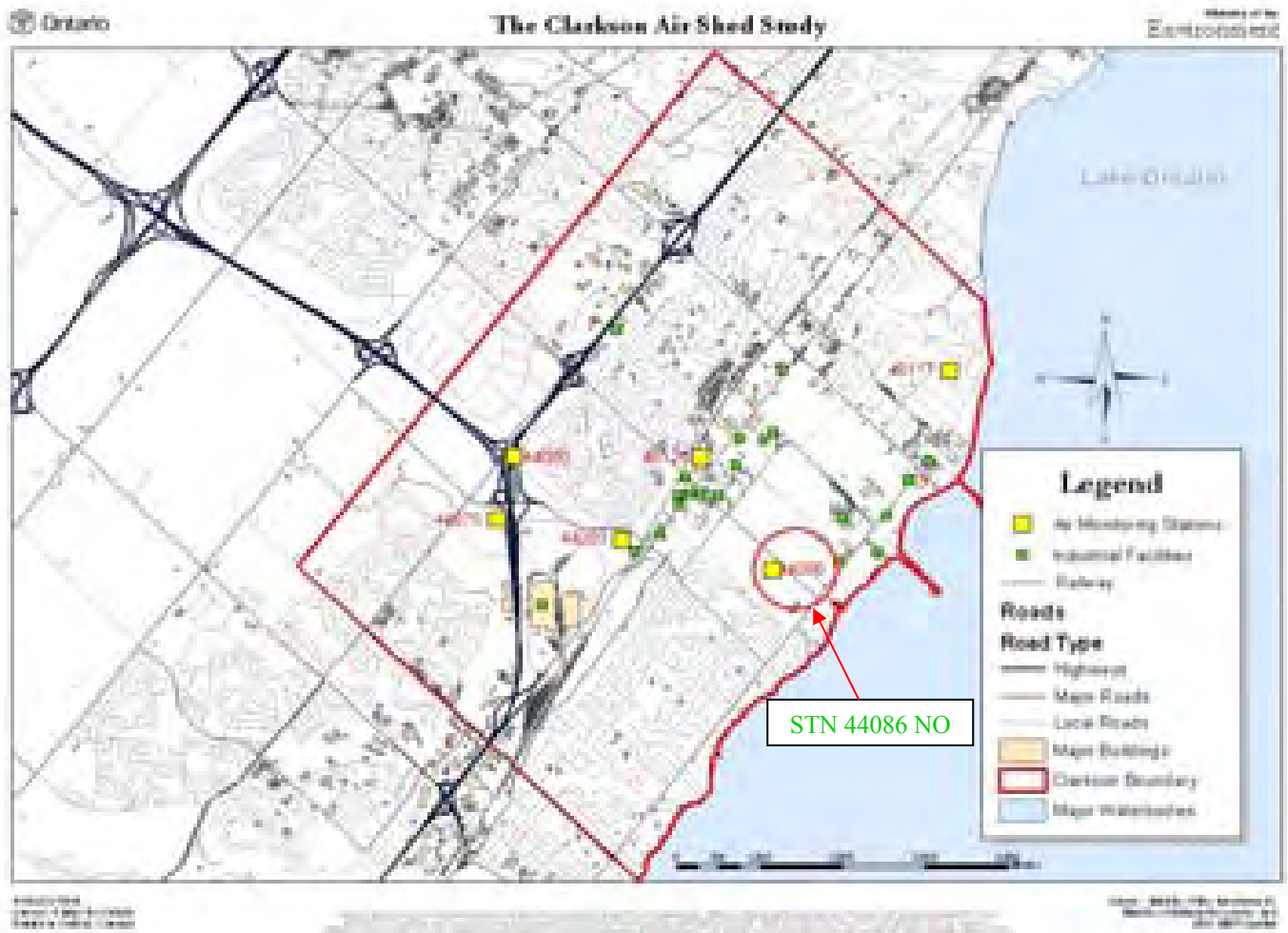
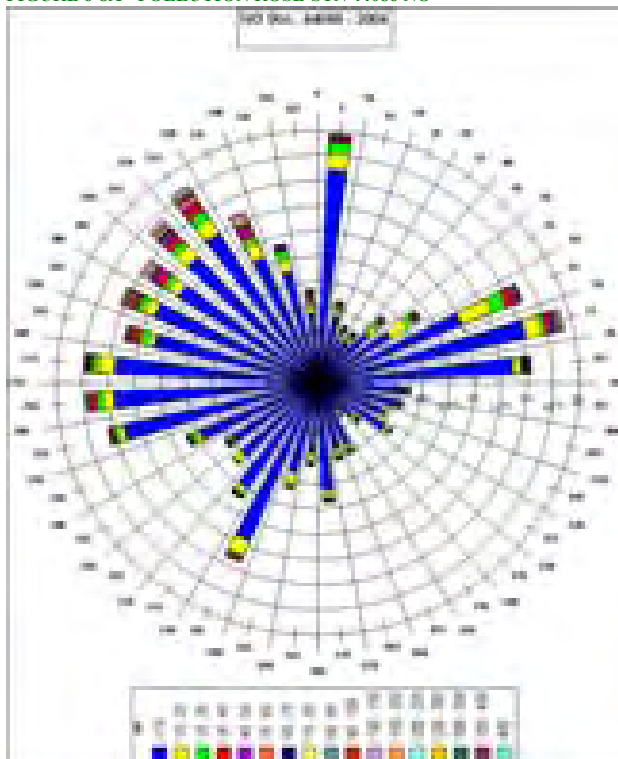
FIGURE 6-6B - AVG / MAX SECTOR CONCENTRATION STN 44080 NO





**FIGURE 6-7B – AVG / MAX SECTOR CONCENTRATION STN 44083 NO**



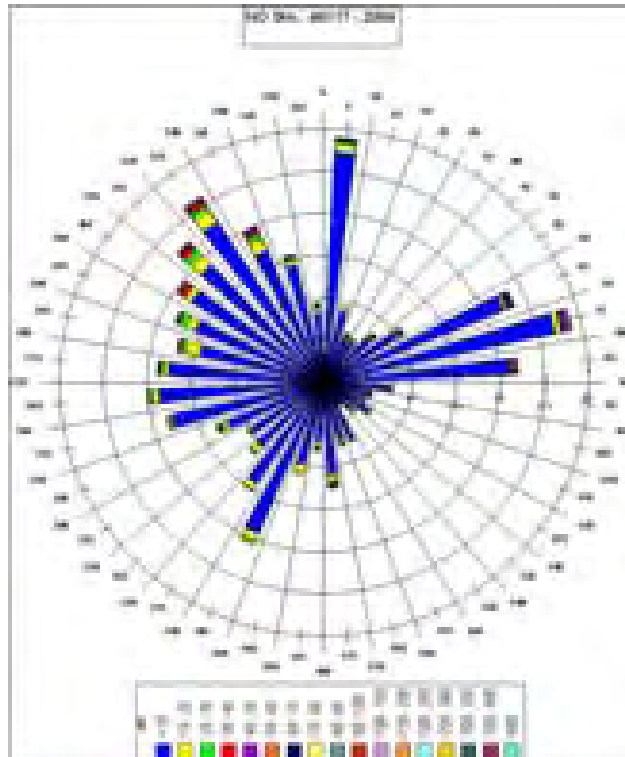
**Figure 6-8 Station Residential [44086] - Nitric Oxide (NO)****FIGURE 6-8A - POLLUTION ROSE-STN 44086 NO**



**Figure 6-9 Station Industrial East [46117] - Nitric Oxide (NO)**



**FIGURE 6-9A POLLUTION ROSE-STN 46117 NO**



**FIGURE 6-9B AVG / MAX SECTOR CONCENTRATION STN 46117 NO**

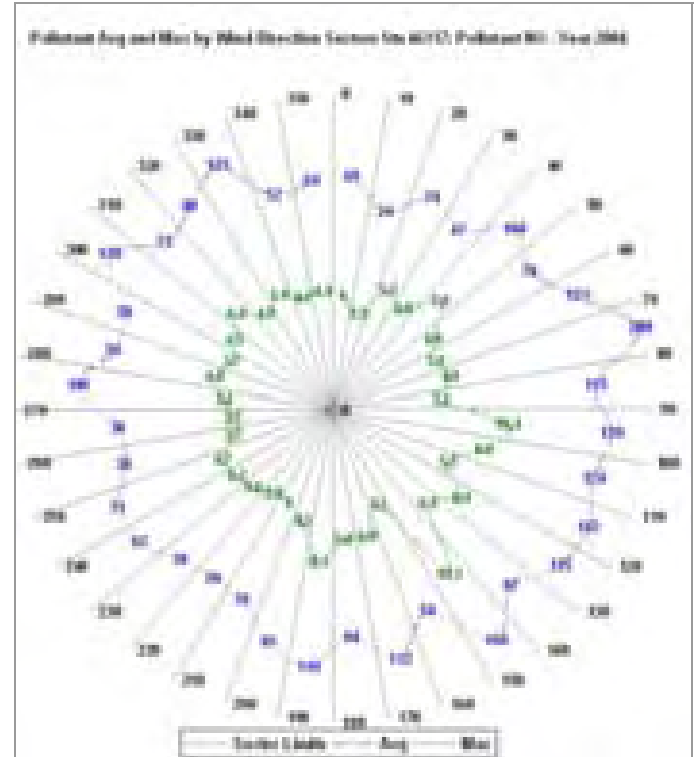


Figure 6-10 Station Industrial Centre [46128] - Nitric Oxide (NO)



FIGURE 6-10A - POLLUTION ROSE-STN 46128 NO

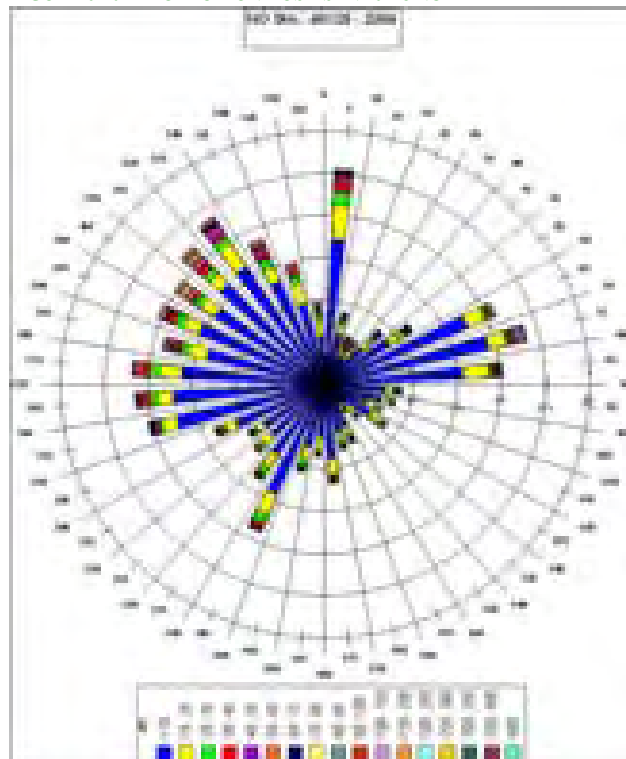
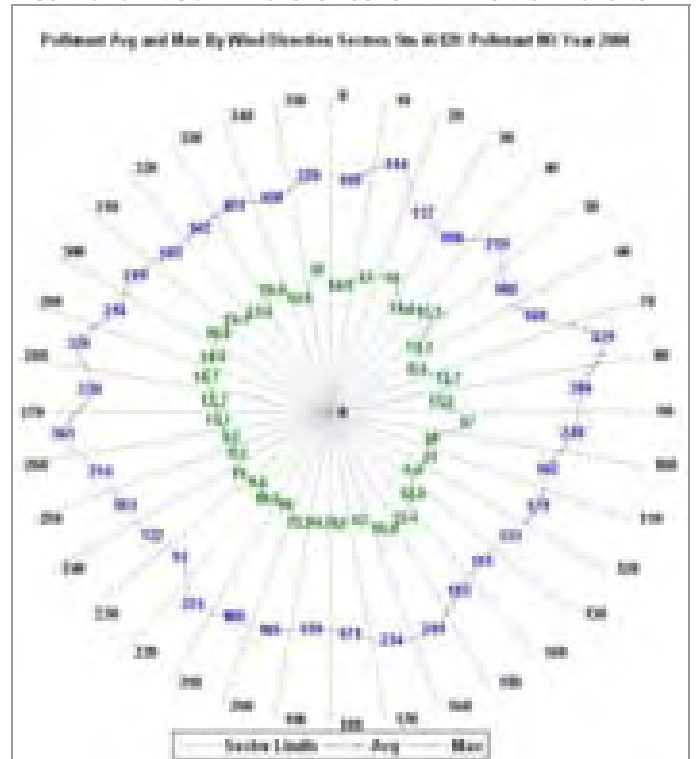


FIGURE 6-10B AVG / MAX SECTOR CONCENTRATION STN 46128 NO

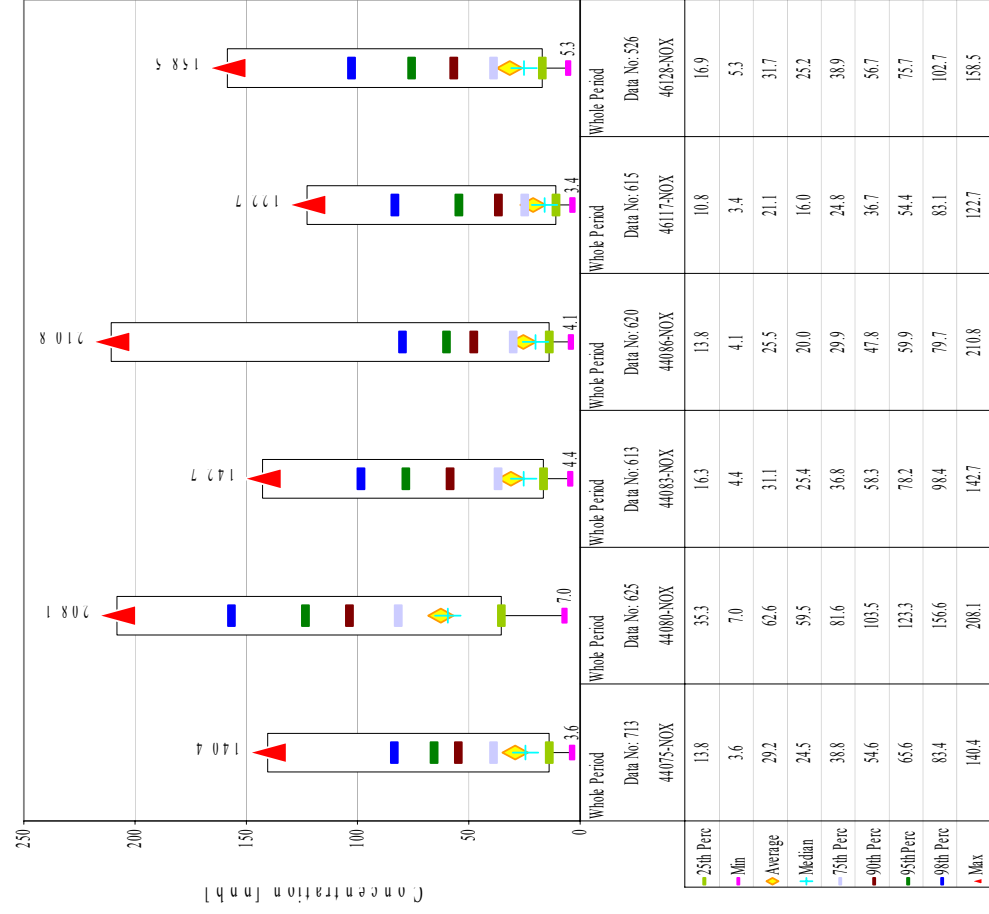
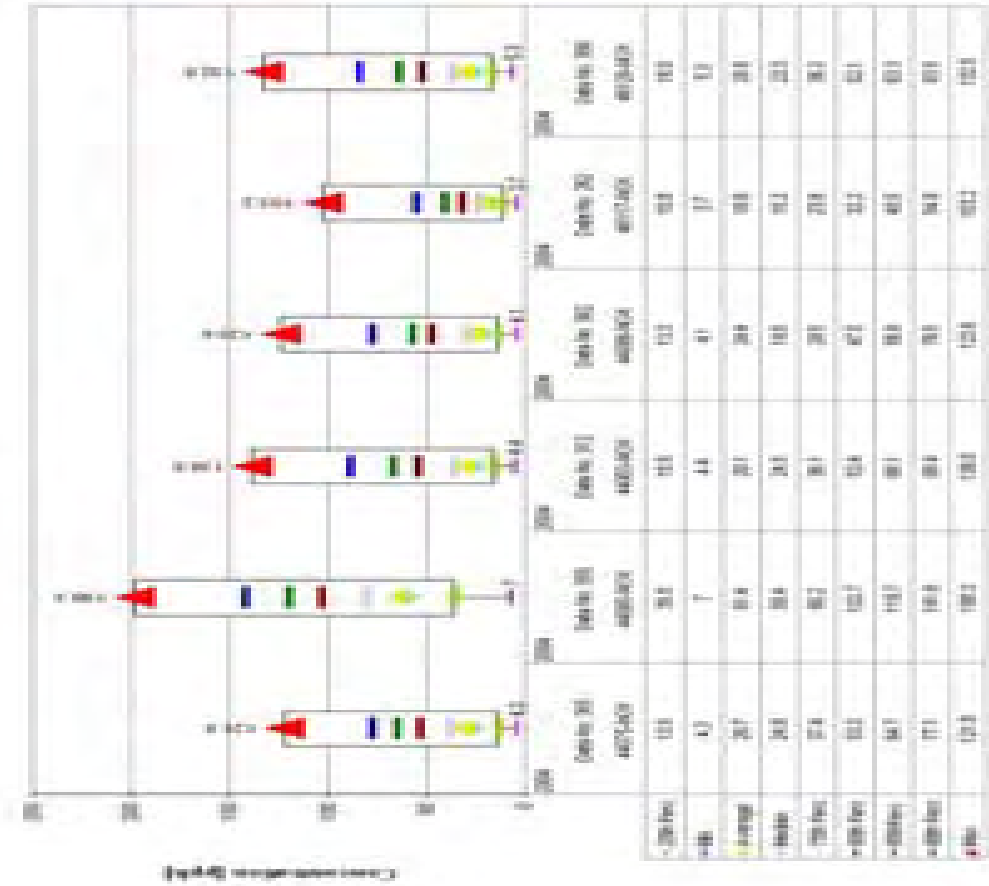


Clarkson: NOx-24 Hr Statistical Report  
2004

A Figure 6-11

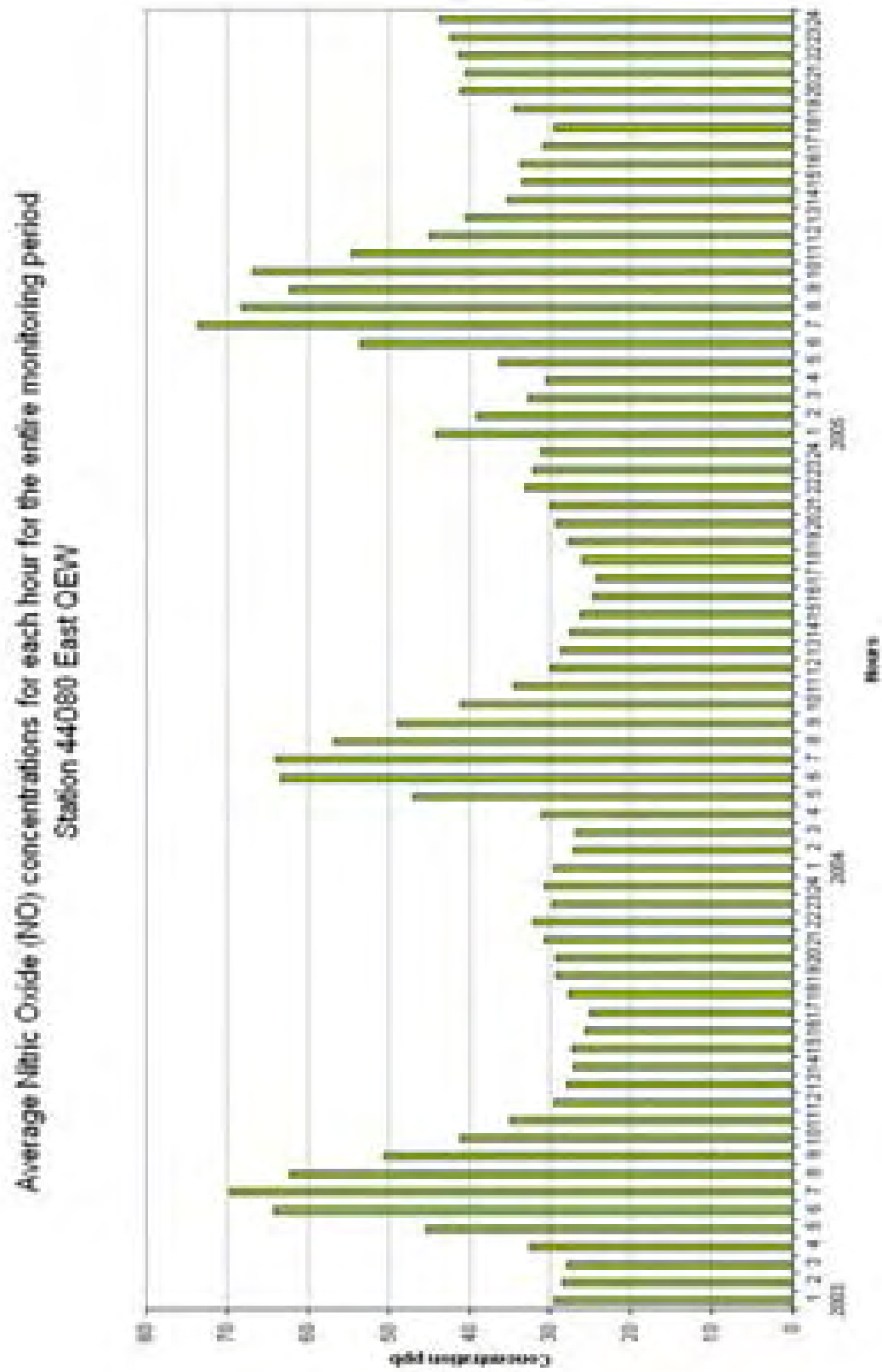
B

Clarkson: NOx-24 Hr Statistical Report  
Whole Period 2003 to 2005



NOTES: (i) STATION NOS: (a) 44075 – QEW West, (b) 44080 – QEW East, (c) 44083 – Residential, (e) 46117 – Ind. East, (f) 46128 – Ind. Centre  
(ii) Number of valid points used in the analysis is depicted in each “box” graph as “Data No.”

Figure 6-12



**Table 6-1 DATA COMPARISON 2004 VS WHOLE MONITORING PERIOD 2003 TO 2005**

Year	44075			44080			44083			44086			46117			46128		
	NO	NO2	NOX	NO	NO2	NOX	NO	NO2	NOX	NO	NO2	NOX	NO	NO2	NOX	NO	NO2	NOX
2004 AVERAGE	10.7	17.9	28.7	35.1	26.0	61.4	12.2	17.5	29.1	9.0	16.0	24.4	4.3	14.1	18.8	13.0	16.0	28.8
2003-2005 AVERAGE	11.2	18.0	29.2	36.5	26.1	62.6	13.6	17.8	31.1	9.3	16.2	25.5	6.5	14.3	21.1	14.8	17.0	31.7
PERCENTAGE	4.7%	.6%	1.7%	4.0%	.4%	2.0%	11.5%	1.7%	6.6%	3.3%	1.3%	4.5%	51.2%	1.4%	12.2%	13.9%	6.3%	10.4%
2004 MAXIMUM	91.5	48.3	121.8	137.6	59.9	198.3	98.5	48.5	138.5	79.6	47.9	123.6	58.5	57.4	103.2	97.0	44.9	132.5
2003-2005 MAXIMUM	103.2	49.0	140.4	155.3	61.7	208.1	98.5	60.9	142.7	118.3	54.5	210.8	84.1	57.4	122.7	110.8	51.3	158.5

NOTE: Station NOS: (a) 44075 – QEW West, (b) 44080 – QEW East, (c) 44083 – Ford Dr, (d) 44086 – Residential, (e) 46117 – Ind. East, (f) 46128 – Ind. Centre

## Section - Seven

# Volatile Organic Compounds (VOCs)

## Clarkson Airshed Study: Part II - The Ambient Air Monitoring Program

### 7.0 Summary of Monitoring for VOC s

VOC samples were collected by drawing ambient air into an evacuated, specially coated, stainless steel canister over a 24-hour period (midnight-to-midnight). Samples were collected following the National Air Pollution Surveillance (NAPS) sampling schedule (every sixth day) for urban sites.

All samples were analyzed for 189 different compounds by gas chromatography/mass spectrometry (GC/MS) at the Environment Canada laboratories in Ottawa (see [Table 7-1](#)).

[Note: Details on the monitoring of VOCs can be found in Section - Four of this report entitled Pollutant Description and Monitoring Methodology].

### 7.1 Discussion of Monitoring Results

Several factors were looked at in the assessment and review of the 189 VOCs identified and the approximately 60,000 VOC data points collected during the VOC study period March 1, 2004 to March 31, 2005.

The actual field sampling for VOCs began in July 2003 and ran until November 2003 using a cartridge sampling method. Difficulties experienced at the laboratory with interferences in the analysis resulted in a switch to the collection of the VOC samples in stainless steel canisters rather than cartridges. The use of the canister method began in March of 2004 and ran until completion of the CAS ambient air monitoring program on March 31/05. The data obtained from the analysis of the VOC cartridge samples taken during July – November 2003 were not used in this report.

The factors used in our assessment of VOC data were:

- Exceedances of specific VOCs as compared to the Ministry 24-hour ambient air quality criteria (AAQC), and Schedule 3 of Ontario Reg. 419 under the Environmental Protection Act
- Comparisons of individual VOC concentrations to those recorded by Environment Canada's National Air Pollution Surveillance Network (NAPS)
- Review of industry emission inventories and modeling data, Reg 127
- Seasonal variations
- Trends and point source impact
- Concentrations of total VOCs versus those for individual compounds

The list of 41 VOCs as shown in **Table 7-2** is referred to as the *Ministry Standard Target List*. This target list was developed by the Ministry to report on the most common VOCs found in the environment and their potential health effects. These target compounds were used to assess the air quality in the CAS study area. Compounds that were not detected during the study period are identified as Non-Detect (ND) in **Table 7.2**.

VOC results from the CAS monitoring program were compared to the 24-hour average standards given in Schedule 3 of O.Reg 419/05. For the VOCs that are not in Reg 419, comparisons were made with available Ministry AAQCs.

The entire VOC data set for 189 compounds that was reviewed and assessed can be found in *Appendix "2"*.

**Table 7-2 Ministry Standard Target List**

VOC Parameter	Non-Detected	O.Reg 419 Schedule 3	AAQC DAILY
1,1-Dichloroethene	ND	600	200
Dichloromethane		220	220
Chloroform		1	
Carbon Tetrachloride		2.4	
1,1-Dichloroethane	ND		200
1,2-Dichloroethane	ND		
1,2-Dibromoethane	ND		
1,1,1-Trichloroethane		115000	
1,1,2-Trichloroethane	ND		
1,1,2,2-Tetrachloroethane	ND		
cis-1,3-Dichloropropene	ND		
1,2-Dichloropropane	ND		
Bromodichloromethane	ND		
Trichloroethylene		12	
Tetrachloroethylene		360	360
Benzene			
Toluene			2000
Ethylbenzene		1000	
m / p-Xylene		730	
o-Xylene		730	
Styrene		400	
1,3,5-Trimethylbenzene			
1,2,4-Trimethylbenzene			1000
Chlorobenzene			
1,3-Dichlorobenzene	ND		
1,4-Dichlorobenzene		95	
1,2-Dichlorobenzene	ND		
n-Hexane (mixture)		2500	
Cyclohexane		6100	
Isoprene			
Alpha-Pinene	ND		
Naphthalene			22.5
1,3-Butadiene			
Acrylonitrile		0.6	
Additional Compounds			
Acrolein		0.08	
1,2,3 Trimethylbenzene			
Butane			
Bromoform			55
Decene,1-			60,000
1-Octene			50,000
Vinyl Chloride		1	

### 7.1.1 VOC Statistical Reports

Statistical reports were prepared for 22 of the 41 selected MOE target compounds.

Compounds that were non-detectable or for which very low annual average concentrations were reported were not assessed using statistical reports. The reports shown in **Figures 7-1, 7-2, 7-3** illustrate minimum, average and maximum values for the whole monitoring period (1 year - 60 samples) relative to the 22 VOCs assessed.

One additional VOC, acrylonitrile, was also assessed in some detail as a result of potential concern with respect to the comparison of CAS study area measured concentrations with a proposed Schedule 3 O.Reg 419/05 value for the compound. However, there is no statistical report available for this compound.

- [Notes: (i) CAS Station numbers are included only on **Figure 7-1** to assist the reader in reviewing the data as reported. However, these numbers apply to **Figure 7-2** and **Figure 7-3** as well.
- (ii) The statistical report and detailed evaluation of xylenes addresses this compound as being equal to m/p - xylene + o - xylene].

### 7.1.2 Comparision of VOC Concentrations with Ontario NAPS Station Data

CAS study area VOC data from the above mentioned statistical reports were compared to the 2004 VOC data base available from 12 of the Environment Canada National Air Pollution Surveillance (NAPS) stations which are located in Ontario. These stations are located in the following cities: Toronto (4), Brampton, Windsor, Hamilton, Sarnia, Kingston, Ottawa, Kitchener and London.

The CAS study area data set included all six monitoring stations. The 24 hour average

samples of the six stations were compared to the annual average of the 12 NAPS stations for 17 selected VOCs (all of the 23 Ministry VOCs for which NAPS station data exists). CAS study area versus Ontario NAPS comparisons are illustrated in **Figures 7-4, 7-5** and **7-6**. In reviewing these comparisons, it is clear that several factors influenced the results and conclusions: (i) location of the sampling station; and (ii) local emission sources.

It is important to note that, as was the case in comparing CAS study area PM<sub>2.5</sub> and NO<sub>x</sub> data with Ministry AQI station data, the NAPS network is an ambient air quality monitoring network and is not set up to identify specific sources. Consequently, the comparison made between CAS and Ontario data is intended only to put some context to the study area data as collected during the ambient air monitoring program.

With respect to the 17 selected VOCs which formed part of this comparison, the following was found:

- (i) the CAS study area concentrations for 6 out of these 17 VOCs, were higher than those for the 12 NAPS stations; these were: toluene, xylene, styrene, ethyl benzene, trichloroethene and acrolein);
- (ii) the CAS concentration for cyclohexane was almost identical to that measured at the Ontario stations;
- (iii) the CAS study area concentrations for the remaining 10 of the 17 VOCs were higher at the Ontario NAPS stations than at CAS stations (these VOCs were: benzene, hexane, 1,2,3-trimethylbenzene, butane, tetrachloroethene, dichlorobenzene, isoprene, 1,2,4 - trimethylbenzene, 1,3 butadiene and naphthalene).

### 7.1.3 Total VOCs

The average total VOC concentration is the cumulative value of the 189 individual



compounds averaged over the total number of VOC sampling days (60) in the CAS ambient air monitoring program. *Stn Industrial East* and *Stn Industrial Centre*, both of which were located in close proximity to a local industrial area recorded VOC annual average concentrations which were 30% higher than *Stn QEW West*. *Stn QEW West* is considered representative of residential / background. (see **Figure 7-8**)

#### 7.1.4 Individual VOCs

A preliminary assessment of all 189 VOCs was undertaken as part of this study. A further comprehensive assessment of 23 of the MOE target list of compounds was carried out during the preparation of this report. The following is a summary of the results of that assessment and with the exception of acrylonitrile, is based on the statistical reports shown in **Figures 7-1 to 7-3**.

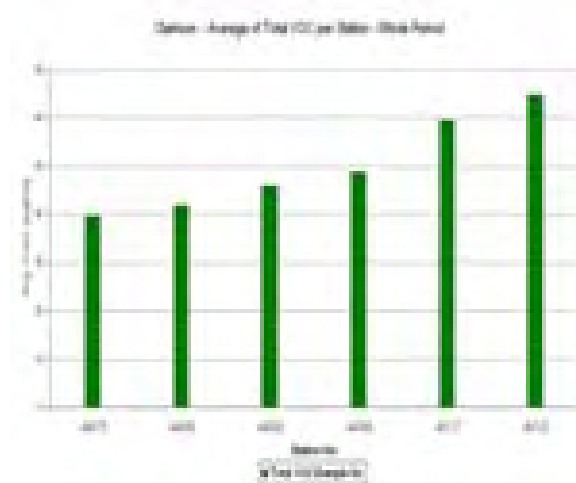
##### Dichloromethane (Methylene Chloride)

*Dichloromethane is used as an industrial solvent and as a paint stripper. It may also be found in some aerosol and pesticide products and is used in the manufacture of photographic film.*

Dichloromethane was the only compound that exceeded the Ministry 24 hour AAQC and Reg 419 Schedule 3 standard of 220  $\mu\text{g}/\text{m}^3$ . The exceedance occurred on only one day, June 20, 2004, when a value of 245  $\mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. The annual average concentration at this station was 6.23  $\mu\text{g}/\text{m}^3$ , and it was higher than the annual average for dichloromethane recorded for any other CAS station. *Stn QEW West* recorded the lowest annual average of 0.48  $\mu\text{g}/\text{m}^3$ . [see **Figure 7-1-A**]

There was no NAPS data on dichloromethane available for comparison.

**Figure 7-8**



##### Toluene

*Toluene is a clear, colourless liquid with a distinctive smell. Toluene occurs naturally in crude oil. It is also produced in the process of manufacturing gasoline and other fuels from crude oil and manufacturing coke from coal. Toluene is used in making paints, paint thinners, fingernail polish, lacquers, adhesives, and rubber and in some printing and leather tanning processes.*

*Stn Industrial Centre* reported the highest annual average for toluene of 6.09  $\mu\text{g}/\text{m}^3$  while *Stn QEW West* reported the lowest annual average of 2.54  $\mu\text{g}/\text{m}^3$ . The maximum 24 hour value for toluene of 116.82  $\mu\text{g}/\text{m}^3$  was also recorded at *Stn Industrial Centre*. The Ministry 24 hour AAQC for toluene is 2000  $\mu\text{g}/\text{m}^3$ . [see **Figure 7-1-B**]

The highest annual average of toluene obtained from the Ontario NAPS stations was 5.36  $\mu\text{g}/\text{m}^3$ . The overall average across the CAS study area was 3.91  $\mu\text{g}/\text{m}^3$  which was 4 % higher than the Ontario NAPS average of 3.75  $\mu\text{g}/\text{m}^3$ . [see **Figure 7-4**]

##### Benzene

*Benzene is a colorless liquid with a sweet odour. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable and is formed from both natural processes and human activities.*

*Some industries use benzene to make other chemicals, which are in turn used to make plastics, resins, as well as nylon and synthetic fibers. Benzene is also used to make some types of rubbers, lubricants, dyes, detergents, drugs,*

and pesticides. Natural sources of benzene include volcanoes and forest fires. Benzene is also a natural part of crude oil, gasoline, and cigarette smoke. It reacts with other chemicals in the air and breaks down within a few days.

*Stn Industrial East* reported the highest annual average for benzene of  $0.92 \mu\text{g}/\text{m}^3$  while *Stn QEW West* reported the lowest annual average of  $0.68 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value of  $7.03 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. There is no Ministry 24 hour AAQC or O.Reg 419/05 Schedule 3 standard for benzene. [see **Figure 7-1-C**]

The highest annual average for benzene, obtained from the Ontario NAPS stations, was  $1.75 \mu\text{g}/\text{m}^3$ . The overall average across the CAS study area was  $0.82 \mu\text{g}/\text{m}^3$  which was 42% lower than the Ontario NAPS average of  $1.16 \mu\text{g}/\text{m}^3$ . [see **Figure 7.4**]

### Ethylbenzene

*Ethylbenzene is a colourless, flammable liquid that smells like gasoline. It is found in natural products such as coal tar and petroleum and is also found in manufacturing products such as inks, insecticides, and paints. Ethyl benzene is used primarily to make another chemical, styrene. Other uses include as a solvent in fuels.*

*Stn Industrial Centre* reported the highest annual average for ethylbenzene of  $1.46 \mu\text{g}/\text{m}^3$  while *Stn QEW West* reported the lowest annual average of  $0.40 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value of  $9.63 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. The Ministry's 24 hour O. Reg 419/05 Schedule 3 standard for ethyl benzene is  $1000 \mu\text{g}/\text{m}^3$ . [see **Figure 7-1-C**]

The highest annual average for ethylbenzene obtained from the Ontario NAPS stations was  $0.82 \mu\text{g}/\text{m}^3$ . The overall average across the CAS study area was  $0.76 \mu\text{g}/\text{m}^3$ , which was 27 % higher than the Ontario NAPS average of  $0.60 \mu\text{g}/\text{m}^3$ . [see **Figure 7-5**]

### Xylenes

*Xylene is primarily a synthetic chemical. Chemical industries produce xylene from petroleum. Xylene also occurs naturally in petroleum and coal tar and is formed during forest fires, to a small extent. It is a colorless, flammable liquid with a sweet odour.*

*Xylene is a mixture of three isomers (ortho [o-xylene], meta [m-xylene] and para [p-xylene]). These values are added together for a total Xylene value.*

*Stn Industrial Centre* reported the highest annual average for xylenes of  $6.08 \mu\text{g}/\text{m}^3$  while *Stn QEW West* reported the lowest annual average of  $1.53 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value for xylene of  $42.97 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. The Ministry's 24 hour Reg 419/05 Schedule 3 standard for xylene is  $730 \mu\text{g}/\text{m}^3$ . [see **Figure 7-1-D**]

The highest annual average for xylene at the Ontario NAPS stations was  $3.25 \mu\text{g}/\text{m}^3$ . The overall average across the CAS study area for xylene was  $3.11 \mu\text{g}/\text{m}^3$  which was 24 % higher than the Ontario NAPS average of  $2.36 \mu\text{g}/\text{m}^3$ . [see **Figure 7-4**]

### 1,4-Dichlorobenzene

*1,4-Dichlorobenzene is a colorless to white solid with a strong, pungent odour. When exposed to air, it slowly changes from a solid to a vapor. Most people can smell 1,4-dichlorobenzene in the air at very low levels.*

*Stn Industrial Centre* reported the highest annual average for 1,4-dichlorobenzene of  $0.06 \mu\text{g}/\text{m}^3$ . Three of the other CAS stations reported the lowest annual average of  $0.04 \mu\text{g}/\text{m}^3$ . The maximum 24 hour values of  $0.25 \mu\text{g}/\text{m}^3$  were recorded at *Stn Residential* and *Stn QEW East*. The Ministry's O.Reg. 419/05 Schedule 3 standard for 1,4 dichlorobenzene is  $95 \mu\text{g}/\text{m}^3$ . [see **Figure 7-2-A**]

The highest annual average for 1,4-dichlorobenzene at the Ontario NAPS stations was  $0.52 \mu\text{g}/\text{m}^3$ . The overall average for 1,4-dichlorobenzene across the CAS study area was  $0.05 \mu\text{g}/\text{m}^3$ , which was 65 % lower than the annual average of  $0.14 \mu\text{g}/\text{m}^3$  for the Ontario NAPS stations. [see **Figure 7-5**]

### Chlorobenzene

*Chlorobenzene is a colorless, flammable liquid with an aromatic, almond-like odor. Some of it will dissolve in water, but it readily evaporates into air. It does not occur naturally in the environment. It is used as a solvent for some pesticide formulations, to degrease automobile parts, and as a chemical intermediate to make several other chemicals.*

*Chlorobenzene released to air is slowly broken down by reactions with other chemicals and sunlight or can be removed by rain.*

*Stn QEW West* reported the highest maximum 24-hour value for chlorobenzene of  $0.10 \mu\text{g}/\text{m}^3$ . The annual averages at all six sites were at or below the analytical detection limit. There is no Ministry 24 hour AAQC or O.Reg 419/05 Schedule 3 standard for chlorobenzene [see **Figure 7-2-A**]

There was no data available for this parameter from Ontario NAPS stations.

### Isoprene (2 – Methyl – 1,3 – Butadiene)

*Isoprene is the predominant VOC emitted by forest species such as poplar, oak, willow, sycamore and eucalyptus making up as much as 80 %. Several studies in recent years have shown isoprene to be a key VOC in troposphere chemistry on both regional and global scales. Emissions appear to be higher than that of any other non-methane hydrocarbon.*

Both *Stn QEW East* and *Stn Ford Dr.* recorded the highest annual average for isoprene of  $0.14 \mu\text{g}/\text{m}^3$  while *Stn Industrial Centre* reported the lowest annual average of  $0.10 \mu\text{g}/\text{m}^3$ . The maximum 24-hour value of  $0.92 \mu\text{g}/\text{m}^3$  was reported at *Stn Residential*. There is no Ministry 24 hour AAQC or O.Reg 419/05 Schedule 3 standard for isoprene. [see **Figure 7-2-B**]

The highest annual average of isoprene obtained from the Ontario NAPS stations was  $0.47 \mu\text{g}/\text{m}^3$ . The overall average across the CAS study area of  $0.13 \mu\text{g}/\text{m}^3$  was 54% lower than the Ontario NAPS average of  $0.28 \mu\text{g}/\text{m}^3$ . [see **Figure 7-5-C**]

### Naphthalene

*Naphthalene is a crystalline, aromatic, white, solid hydrocarbon, best known as the primary ingredient of mothballs. Naphthalene is volatile, forming a flammable vapor. It is manufactured from coal tar, and converted to phthalic anhydride for the manufacture of plastics, dyes and solvents.*

*Stn Ford Dr.* reported the highest annual average for naphthalene of  $0.22 \mu\text{g}/\text{m}^3$  while *Stn QEW West* reported the lowest annual average of  $0.12 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value of  $0.86 \mu\text{g}/\text{m}^3$  was recorded at *Stn QEW East*. The Ministry's 24 hour

AAQC for naphthalene is  $22.5 \mu\text{g}/\text{m}^3$ . [see **Figure 7-2-B**]

The highest annual average obtained for naphthalene at the Ontario NAPS stations was  $0.47 \mu\text{g}/\text{m}^3$ . The CAS study area overall average of  $0.16 \mu\text{g}/\text{m}^3$  was 43 % lower than the Ontario NAPS average of  $0.28 \mu\text{g}/\text{m}^3$ . [see **Figure 7-6**]

### 1,2,3-Trimethylbenzene

*1,2,3-Trimethylbenzene is used in production of petroleum and coal tar and as a solvent for resins*

*Stn Ford Dr.* reported the highest annual average for 1,2,3-trimethylbenzene of  $0.11 \mu\text{g}/\text{m}^3$  while *Stn QEW West* reported the lowest annual average of  $0.06 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value of  $0.69 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. [see **Figure 7-2-C**] There is no Ministry 24 hour AAQC or O.Reg 419/05 Schedule 3 standard for 1,2,3 – trimethylbenzene.

The highest annual average for 1,2,3 - trimethylbenzene recorded for the Ontario NAPS stations was  $0.20 \mu\text{g}/\text{m}^3$ . The CAS study area overall average of  $0.08 \mu\text{g}/\text{m}^3$  was 43% lower than the Ontario NAPS average of  $0.14 \mu\text{g}/\text{m}^3$ . [see **Figure 7-6**]

### 1,2,4-Trimethylbenzene

*1,2,4-Trimethylbenzene is a color-less, flammable liquid. It occurs naturally in coal tar and petroleum crude oil. It is a major component of a petroleum refinery distillation*

*Stn Industrial Centre* reported the highest annual average ( $0.56 \mu\text{g}/\text{m}^3$ ) while *Stn QEW West* reported the lowest annual average of  $0.26 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value of  $4.96 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. The Ministry's 24 hour AAQC for 1,2,4-trimethylbenzene is  $1000 \mu\text{g}/\text{m}^3$ . [see **Figure 7-2-C**]

The highest annual average for 1,2,4-trimethylbenzene recorded for the Ontario stations was  $0.85 \mu\text{g}/\text{m}^3$ . The CAS study area overall average of  $0.41 \mu\text{g}/\text{m}^3$  was 28% lower than the Ontario NAPS average of  $0.57 \mu\text{g}/\text{m}^3$ . [see **Figure 7-5**]

### 1,3,5-Trimethylbenzene

*1,3,5-Trimethylbenzene is an aromatic hydrocarbon. It is commonly used as a solvent in research and industry.*

*Stn Industrial Centre* reported the highest annual average for 1,3,5-trimethylbenzene was  $0.17 \mu\text{g}/\text{m}^3$  while *Stn QEW West* reported the lowest annual average of  $0.08 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value of  $1.32 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. [see **Figure 7-2-C**]. There is no Ministry 24 hour AAQC or O.Reg. 419/05 Schedule 3 standard for 1,3,5-trimethylbenzene.

There was no NAPS data for 1,3,5-trimethylbenzene available for comparison with the CAS station data.

### Cyclohexane

*A pungent, saturated, cyclic hydrocarbon found in petroleum or made synthetically. Used as a solvent and in organic synthesis*

*Stn Industrial East* reported the highest annual average for cyclohexane  $0.67 \mu\text{g}/\text{m}^3$ , while both *Stn QEW West* and *Stn QEW East* reported the lowest annual average  $0.12 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value of  $5.27 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial East*. The Ministry's O.Reg 419/05 Schedule 3 standard for cyclohexane is  $6100 \mu\text{g}/\text{m}^3$ . [see **Figure 7-2-D**]

The highest annual average for cyclohexane recorded at the Ontario NAPS stations was  $1.54 \mu\text{g}/\text{m}^3$ . The CAS study area overall average of  $0.28 \mu\text{g}/\text{m}^3$  was only 1% lower than Ontario NAPS average of  $0.30 \mu\text{g}/\text{m}^3$ . [see **Figure 7-4**]

### Hexane

*n-Hexane is a chemical made from crude oil. Pure n-hexane is a colorless liquid with a slightly disagreeable odor. It is highly flammable, and its vapors can be explosive. Solvents such as n-hexane are also used as cleaning agents in the printing, textile, furniture, and shoemaking industries. Certain kinds of special glues used in the roofing and shoe and leather industries also contain n-hexane. Several consumer products contain n-hexane, such as gasoline, quick-drying glues used in various hobbies, and rubber cement.*

*Stn Industrial East* reported the highest annual average for n-hexane of  $1.48 \mu\text{g}/\text{m}^3$  while *Stn QEW West* reported the lowest annual average of  $0.51 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value of  $12.36 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. The

Ministry's 24 hour O.Reg 419/05 Schedule 3 standard for n-hexane is  $2500 \mu\text{g}/\text{m}^3$ . [see **Figure 7-2**]

The highest annual average for n-hexane recorded at the Ontario NAPS stations was  $2.33 \mu\text{g}/\text{m}^3$ . The CAS study area overall average of  $0.86 \mu\text{g}/\text{m}^3$  was 22% lower than the Ontario NAPS average of  $1.10 \mu\text{g}/\text{m}^3$ . [see **Figure 7-4**]

### Butane

*Butane occurs in natural gas, petroleum and refinery gases. It shows little chemical reactivity at ordinary temperatures but burns readily when ignited in air.*

*Stn Industrial East* reported the highest annual average for butane was  $4.65 \mu\text{g}/\text{m}^3$  while *Stn QEW West* reported the lowest annual average of  $2.47 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value of  $23.53 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. There is no Ministry 24 hour AAQC or O.Reg 419/05 Schedule 3 standard for butane. [see **Figure 7-3-A**]

The highest annual average for butane recorded at the Ontario stations was  $5.39 \mu\text{g}/\text{m}^3$ . The CAS study area overall average of  $3.36 \mu\text{g}/\text{m}^3$  was 15% lower than the Ontario NAPS average of  $3.93 \mu\text{g}/\text{m}^3$ . [see **Figure 7-4**]

### Styrene

*Styrene is primarily a synthetic chemical. It's a colorless liquid that evaporates easily and has a sweet smell. It often contains other chemicals that give it a sharp, unpleasant smell. Styrene enters the environment during the manufacture, use, and disposal of styrene-based products. It can be found in air, water, and soil. It is quickly broken down in the air, usually within 1 to 2 days*

*Stn Industrial Centre* reported the highest annual average for styrene of  $0.81 \mu\text{g}/\text{m}^3$  while *Stn Industrial East* reported the lowest annual average of  $0.23 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value  $10.02 \mu\text{g}/\text{m}^3$  was recorded at *Stn QEW West*. The Ministry's 24 hour O.Reg 419/05 Schedule 3 standard for styrene is  $400 \mu\text{g}/\text{m}^3$ . [see **Figure 7-3-A**]

The highest annual average for styrene recorded at the Ontario NAPS stations was  $1.54 \mu\text{g}/\text{m}^3$ . The overall average across the CAS study area for styrene was  $0.53 \mu\text{g}/\text{m}^3$  which was 55% higher than the Ontario NAPS average of  $0.24 \mu\text{g}/\text{m}^3$ . [see **Figure 7-4**]

### **Tetrachloroethene (Tetrachloroethylene or Perchloroethylene)**

*Tetrachloroethene is a manufactured chemical that is widely used in dry-cleaning of fabrics, including clothes. It is also used for degreasing metal parts and in the manufacturing of other chemicals. Tetrachloroethene is found in consumer products, including some paints and spot removers, water repellents, brakes and wood cleaners, glues, and suede protectors.*

*Stn Industrial Centre* reported the highest annual average for tetrachloroethene of  $0.28 \mu\text{g}/\text{m}^3$  while *Stn QEW West* reported the lowest annual average of  $0.15 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value of  $3.77 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. The Ministry's 24 hour AAQC and O.Reg 419/05 Schedule 3 standard for tetrachloroethene is  $360 \mu\text{g}/\text{m}^3$ . [see **Figure 7-3-B**]

The highest annual average for tetrachloroethene obtained for the Ontario stations was  $0.54 \mu\text{g}/\text{m}^3$ . The CAS study area overall average of  $0.20 \mu\text{g}/\text{m}^3$  was 20% lower than the Ontario average of  $0.25 \mu\text{g}/\text{m}^3$ .

### **Trichloroethene (Trichloroethylene)**

*Trichloroethylene (TCE) is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. It is used mainly as a solvent to remove grease from metal parts, but it is also an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers.*

*Stn Industrial Centre* reported the highest annual average for trichloroethene of  $0.24 \mu\text{g}/\text{m}^3$  while *Stn QEW West* reported the lowest annual average of  $0.14 \mu\text{g}/\text{m}^3$ . The maximum 24-hr value of  $2.53 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. The Ministry's 24 hour O.Reg 419/05 Schedule 3 standard for trichloroethene is  $12 \mu\text{g}/\text{m}^3$ . [see **Figure 7-3-B**]

The highest annual average for trichloroethene obtained from the Ontario NAPS stations was  $0.36 \mu\text{g}/\text{m}^3$ . The CAS study area overall average of  $0.18 \mu\text{g}/\text{m}^3$  was identical to the Ontario NAPS average of  $0.18 \mu\text{g}/\text{m}^3$ . [see **Figure 7-6**]

### **Carbon tetrachloride**

*Carbon tetrachloride is a manufactured chemical that does not occur naturally. It is a clear liquid with a sweet smell that can be detected at low levels. Carbon*

*tetrachloride is most often found as a colorless gas. It is not flammable and does not dissolve in water very easily. It was used in the production of refrigeration fluid and propellants for aerosol cans, as a pesticide, as a cleaning fluid and degreasing agent, in fire extinguishers, and in spot removers. Because of its harmful effects, these uses are now banned and it is only used in some industrial applications. It moves very quickly into the air upon release and is very stable in air*

Carbon tetrachloride values were consistent across the Clarkson Airshed ranging from  $0.56 \mu\text{g}/\text{m}^3$  to  $0.59 \mu\text{g}/\text{m}^3$ . The highest annual averages were also consistent ranging from  $0.70 \mu\text{g}/\text{m}^3$  to  $0.78 \mu\text{g}/\text{m}^3$ . The Ministry's 24 hour O.Reg 419/05 Schedule 3 standard for carbon tetrachloride is  $2.4 \mu\text{g}/\text{m}^3$ . [see **Figure 7-3-C**]

Both CAS study area stations and Ontario NAPS stations reported similar annual averages ranging from  $0.58 \mu\text{g}/\text{m}^3$  to  $0.65 \mu\text{g}/\text{m}^3$ , although the CAS values were 10% lower. [see **Figure 7-7**]

### **Chloroform (Trichloromethane or Methyl – Trichloride)**

*Most chloroform in air eventually breaks down but it is a slow process. Chloroform is a colorless liquid with a pleasant, nonirritating odour and a slightly sweet taste. It will burn only when it reaches very high temperatures. Chloroform is used to make other chemicals and can also be formed in small amounts when chlorine is added to water. Chloroform evaporates easily into the air*

Annual average chloroform concentrations were consistent across the Clarkson Airshed ranging from  $0.08 \mu\text{g}/\text{m}^3$  to  $0.11 \mu\text{g}/\text{m}^3$ . The maximum 24 hour value of  $0.48 \mu\text{g}/\text{m}^3$  was recorded at *Stn Residential*. The Ministry 24 hour O.Reg 419/05 Schedule 3 standard for chloroform is  $1 \mu\text{g}/\text{m}^3$ . [see **Figure 7-3-C**]

There were no NAPS data available for chloroform.

### **1,3-Butadiene**

*1,3- Butadiene is a chemical made from processing of petroleum. It is also used to make plastic including acrylics. Small amounts can be found in gasoline. It breaks down quickly (2 hrs) in air by sunlight.*

*Stn QEW East* reported the highest annual average of  $0.10 \mu\text{g}/\text{m}^3$  for 1,3-butadiene while *Stn Industrial East* recorded the lowest annual average  $0.05 \mu\text{g}/\text{m}^3$ .



The maximum 24-hour value of  $0.33 \mu\text{g}/\text{m}^3$  was recorded at *Stn Industrial Centre*. There is no O.Reg 419/05 Schedule 3 standard or AAQC for 1,3-butadiene [see **Figure 7-3-D**]

The highest annual average for 1,3-butadiene obtained from the Ontario NAPS stations was  $0.34 \mu\text{g}/\text{m}^3$ . The CAS study area overall average of  $0.08 \mu\text{g}/\text{m}^3$  was 30% lower than the Ontario NAPS annual average of  $0.11 \mu\text{g}/\text{m}^3$ .

### Acrylonitrile

*Acrylonitrile is a pungent smelling, toxic, extremely flammable organic liquid and is classified as a possible human carcinogen. It is also known as cyanoethylene or vinyl cyanide. Acrylonitrile is used as a precursor monomer in the manufacture of synthetic polymers, especially polyacrylonitrile, acrylic fibers, nylon, and synthetic rubber. Small amounts are also used as a fumigant.*

A total of 14 samples were collected at selected sites for acrylonitrile analysis. Samples were collected at *Stn QEW West*, *Stn QEW East*, *Stn Ford Dr.*, *Stn Residential* and *Stn Industrial East*. The maximum 24 hour average results obtained at each of these sites were  $0.45 \mu\text{g}/\text{m}^3$ ,  $0.35 \mu\text{g}/\text{m}^3$ ,  $18.31 \mu\text{g}/\text{m}^3$ ,  $9.93 \mu\text{g}/\text{m}^3$ , and  $0.20 \mu\text{g}/\text{m}^3$ . The overall CAS study area average was  $2.19 \mu\text{g}/\text{m}^3$  as compared to the O.Reg 419/05 Schedule 3 standard for acrylonitrile which is  $0.60 \mu\text{g}/\text{m}^3$ .

### Acrolein (2-Propenal)

*Small amounts of acrolein can be formed and enter the air when trees, tobacco, other plants and gasoline, and oil are burned. Acrolein breaks down fairly rapidly in air by reacting with other chemicals and sunlight.*

A total of 12 samples were collected at selected sites for acrolein analysis. Samples were collected at *Stn QEW West*, *Stn QEW East* and *Stn Industrial Centre*. The maximum 24 hour average results obtained at each of these sites were  $0.46 \mu\text{g}/\text{m}^3$ ,  $0.45 \mu\text{g}/\text{m}^3$  and  $0.51 \mu\text{g}/\text{m}^3$ , respectively. The overall average for the CAS study area samples was  $0.25 \mu\text{g}/\text{m}^3$ . The O.Reg 419/05 Schedule 3 standard for acrolein is  $0.08 \mu\text{g}/\text{m}^3$ . [see **Figure 7-3-D**]

The highest annual average for acrolein obtained for the Ontario NAPS stations was  $0.20 \mu\text{g}/\text{m}^3$ . The CAS study area overall average of  $0.25 \mu\text{g}/\text{m}^3$

was 44% higher than the Ontario average of  $0.14 \mu\text{g}/\text{m}^3$ . [see **Figure 7-6**]

It is important to note that in the CAS ambient air monitoring program the sampling for acrolein was carried out using canisters and the analysis was done using Gas Chromatography – Mass Spectrometry (GC-MSD) and a special polar VOC calibration mixture. The Ontario NAPS station samples were obtained using DNPH cartridges and the analysis was done using High Pressure Liquid Chromatography (HPLC). Ministry and Environment Canada staffs were not able to determine the exact cause of the high CAS study area values and could not confirm whether differences in sampling and analytical method may have contributed to the large difference between the CAS study area data and NAPS data.

With respect to the individual VOC data presented and discussed above, daily and yearly averages calculated for *Stn Industrial Centre* were higher than expected due to one sample collected on June 20, 2004. The following compounds: dichloromethane, benzene, toluene, xylene, ethylbenzene, tetrachloroethene, hexane and 1,2,4-trimethylbenzene were all elevated on that day. These recorded values for June 20/04 were also sufficient to affect the annual average recorded in the CAS study area.

From those compounds that were present in elevated concentrations on June 20/04, only dichloromethane exceeded the appropriate Ministry 24-hour AAQC value or the proposed O.Reg. 419 Schedule 3 standard value. (all parameters have standard or criteria values with the exception of benzene, chlorobenzene, isoprene, 1,2,3-trimethyl benzene, 1,3,5-trimethylbenzene and butane).

Despite extensive review by Ministry staff the source of these elevated concentrations could not be determined.

## 7.2 QA/QC Data Verification

Duplicate field VOC monitoring was carried out throughout the sampling program. Co-located

canisters were operated from site to site to verify the operation of all field equipment. All duplicate samples were found to be acceptable. **Figure 7.7** illustrates consistency in the analysis across CAS and the Ontario NAPS locations based on data verification using carbon tetrachloride and 1,1,1-trichloroethane. Both of these compounds have been found in similar concentrations throughout Ontario.

### 7.3 Summary of Results - Observations

Both Stn Industrial East and Stn Industrial Centre, which are located in the industrial zone, recorded total VOC concentrations which were 30% higher than Stn QEW West the station which is considered representative of residential / background.

Dichloromethane was the only compound that exceeded the Ministry 24 hour AAQC and the Reg 419 Schedule 3 standard of  $220 \text{ ug/m}^3$ . On June 20, 2004, a concentration of  $245 \text{ ug/m}^3$  for dichloromethane was recorded at Stn Industrial Centre.

However, the annual average concentration for dichloromethane at Stn Industrial Centre was  $6.23 \text{ ug/m}^3$ . This value is well below the AAQC of  $44 \text{ ug/m}^3$  for dichloromethane.

Several other VOCs were measured at elevated concentrations on June 20, 2004. These were: benzene, toluene, xylene, ethylbenzene, tetrachloroethene, hexane and 1,2,4-trimethylbenzene. However, none of these VOCs exceeded the appropriate AAQC or O.Reg. 419 Schedule 3 standard values (with the exception of benzene which is a known carcinogen and has neither a standard nor a criteria value).

In reviewing the concentrations of 23 of the 41 Ministry VOC target compounds, values for 18 of the 41 were at or near the detection limits of the analytical method and were, therefore, excluded from further assessment.

The annual average concentrations of the 17 VOCs detected in the CAS were compared to the annual average of 12 Ontario NAPS stations [Note: There was no NAPS data available for 5 of the compounds]. Overall, CAS station data is comparable to NAPS station data and somewhat higher than expected for specific VOCs such as xylene, toluene, styrene, ethyl benzene, trichloroethene and acrolein.

Two VOCs of interest, acrolein and acrylonitrile, require further monitoring and assessment. Although there are presently no 24 hr AAQCs for these two compounds, the new standards identified in Schedule 3 of Ministry Regulation 419 would have resulted in measured CAS concentrations exceeding both the acrolein 24 hr value of  $0.08 \text{ ug/m}^3$  and the acrylonitrile 24 hr value of  $0.6 \text{ ug/m}^3$ .

Table 7-1

VOC TARGET COMPOUND LIST (Regular once in 6 day sampling schedule)							
1	Propene	41	t-4-Methyl-2-Pentene	81	2,2-Dimethylhexane	121	Camphene
2	Propane	42	Methyl-t-Butyl Ether ( MTBE )	82	Methylcyclohexane	122	4-Ethyltoluene
3	Freon 22 (Chlorodifluoromethane)	43	2-Methylpentane	83	2,5-Dimethylhexane	123	1,3,5-Trimethylbenzene
4	Freon 12 (Dichlorodifluoromethane)	44	c-4-Methyl-2-Pentene	84	2,4-Dimethylhexane	124	2-Ethyltoluene
5	Propyne	45	3-Methylpentane	85	t-1,3-Dichloropropene	125	b-Pinene
6	Chloromethane	46	1-Hexene/2-Methyl-1-Pentene	86	1,1,2-Trichloroethane	126	1-Decene
7	Isobutane (2-Methylpropane)	47	c-1,2-Dichloroethene	87	Bromotrichloromethane	127	tert-Butylbenzene
8	Freon 114 (1,2-Dichlorotetrafluoroethane	48	Hexane	88	2,3,4-Trimethylpentane	128	1,2,4-Trimethylbenzene
9	Vinylchloride (Chloroethene)	49	Chloroform	89	Toluene	129	Decane
10	1-Butene/2-Methylpropene	50	t-2-Hexene	90	2-Methylheptane	130	Benzyl Chloride
11	1,3-Butadiene	51	2-Ethyl-1-Butene	91	4-Methylheptane	131	1,3-Dichlorobenzene
12	Butane	52	t-3-Methyl-2-Pentene	92	1-Methylcyclohexene	132	1,4-Dichlorobenzene
13	t-2-Butene	53	c-2-Hexene	93	3-Methylheptane	133	iso-Butylbenzene
14	2,2-Dimethylpropane	54	c-3-Methyl-2-Pentene	94	Dibromochloromethane	134	sec-Butylbenzene
15	Bromomethane	55	2,2-Dimethylpentane	95	c-1,3-Dimethylcyclohexane	135	1,2,3-Trimethylbenzene
16	1-Butyne	56	1,2-Dichloroethane	96	t-1,4-Dimethylcyclohexane	136	p-Cymene (1-Methyl-4-Isopropylbenzene)
17	c-2-Butene	57	Methylcyclopentane	97	2,2,5-Trimethylhexane	137	1,2-Dichlorobenzene
18	Chloroethane	58	2,4-Dimethylpentane	98	1,2-Dibromoethane (EDB )	138	Limonene
19	3-Methyl-1-Butene	59	1,1,1-Trichloroethane	99	1-Octene	139	Indan (2,3-Dihydroindene)
20	2-Methylbutane	60	2,2,3-Trimethylbutane	100	Octane	140	1,3-Diethylbenzene
21	Freon 11 (Trichlorofluoromethane)	61	1-Methylcyclopentene	101	t-2-Octene	141	1,4-Diethylbenzene
22	1-Pentene	62	Benzene	102	t-1,2-Dimethylcyclohexane	142	n-Butylbenzene
23	2-Methyl-1-Butene	63	Carbontetrachloride	103	Tetrachloroethene	143	1,2-Diethylbenzene
24	Pentane	64	Cyclohexane	104	c-1,4/t-1,3-Dimethylcyclohexane	144	1-Undecene
25	Isoprene (2-Methyl-1,3-Butadiene)	65	2-Methylhexane	105	c-1,2-Dimethylcyclohexane	145	Undecane
26	t-2-Pentene	66	2,3-Dimethylpentane	106	Chlorobenzene	146	1,2,4-Trichlorobenzene
27	Ethylbromide	67	Cyclohexene	107	Ethylbenzene	147	Naphthalene
28	1,1-Dichloroethene	68	3-Methylhexane	108	m,p-Xylene	148	Dodecane
29	c-2-Pentene	69	Dibromomethane	109	Bromoform	149	Hexachlorobutadiene
30	Dichloromethane	70	1,2-Dichloropropane	110	1,4-Dichlorobutane	150	Hexylbenzene
31	2-Methyl-2-Butene	71	Bromodichloromethane	111	Styrene	151	Ethylene
32	Freon 113 (1,1,2-Trichlorotrifluoroethane	72	1-Heptene	112	1,1,2,2-Tetrachloroethane	152	Acetylene
33	2,2-Dimethylbutane	73	Trichloroethene	113	1-Nonene	153	Ethane
34	Cyclopentene	74	2,2,4-Trimethylpentane	114	o-Xylene		
35	t-1,2-Dichloroethene	75	t-3-Heptene	115	Nonane		
36	4-Methyl-1-Pentene	76	Heptane	116	iso-Propylbenzene		
37	3-Methyl-1-Pentene	77	c-3-Heptene	117	a-Pinene		
38	1,1-Dichloroethane	78	t-2-Heptene	118	3,6-Dimethyloctane		
39	Cyclopentane	79	c-2-Heptene	119	n-Propylbenzene		
40	2,3-Dimethylbutane	80	c-1,3-Dichloropropene	120	3-Ethyltoluene		
POLAR COMPOUNDS (Selective sampling days)							
154	Acetaldehyde	163	Acrylonitrile (2-Propennitrile)	172	MEK (Methyl ether ketone)	181	2-Pentanone
155	Methanol	164	Carbon Disulfide	173	2-Butanol	182	Pentanal
156	Ethylene oxide	165	Methyl Acetate	174	2-Methylfuran	183	MIBK (Methyl isobutyl ketone)
157	Ethanol	166	2-Methyl-2-Propanal (Isobutylaldehyde)	175	Ethylacetate	184	Isobutylacetate
158	Acetonitrile	167	MAC (2-Methyl-2-propanal)	176	Isobutylalcohol	185	Cyclopentanone
159	Acrolein (2-Propenal)	168	Propyl alcohol (1-Propanol)	177	2-Butenal (Crotonaldehyde)	186	Hexanal
160	Acetone	169	MTBE (Methyl tertiary butyl ether)	178	2-Methylbutanal(Isovaleraldehyde)	187	Butylacetate
161	Propionaldehyde	170	MVK (Methyl vinyl ketone)	179	Isopropylacetate	188	Cyclohexanone
162	Isopropyl Alcohol	171	Butylaldehyde (Butanal)	180	1-Butanol (Butyl alcohol)	189	Benzaldehyde



Carbon - VOC Mts. Res. by Station for the 2016 Monitoring Period

A

FIGURE 7-1

B



Carbon - VOC Mts. Res. by Station for the 2016 Monitoring Period

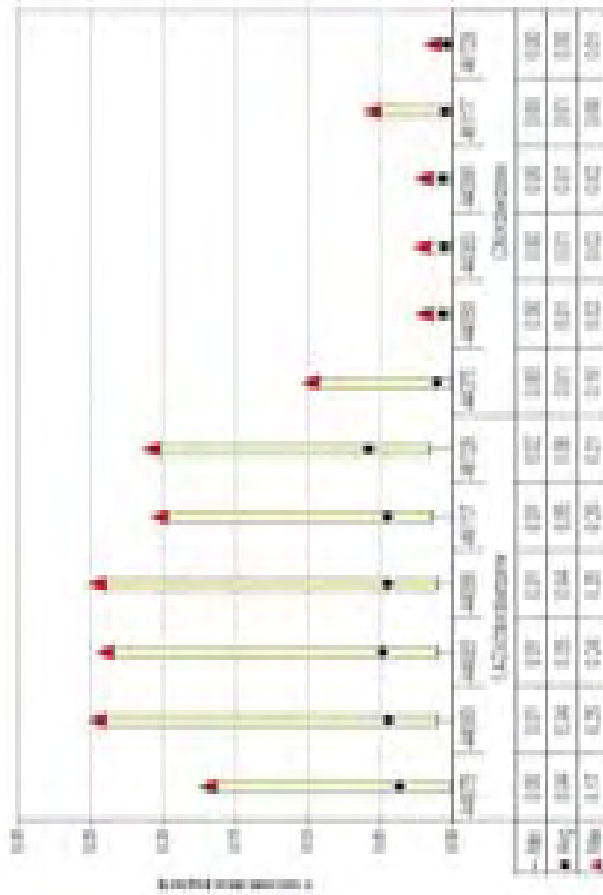
C

FIGURE 7-1

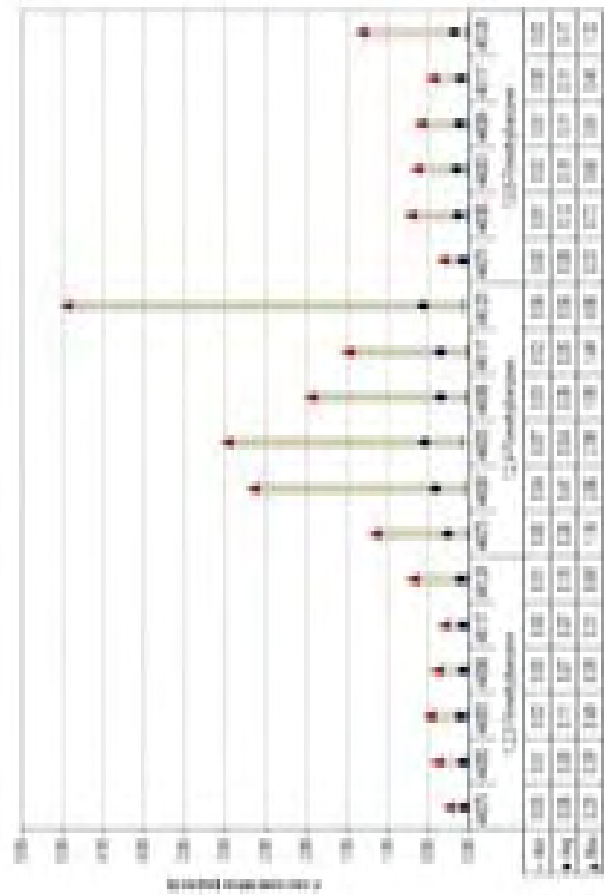
D



**A** **FIGURE 7-2** **B**



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C	FIGURE 7-2	D
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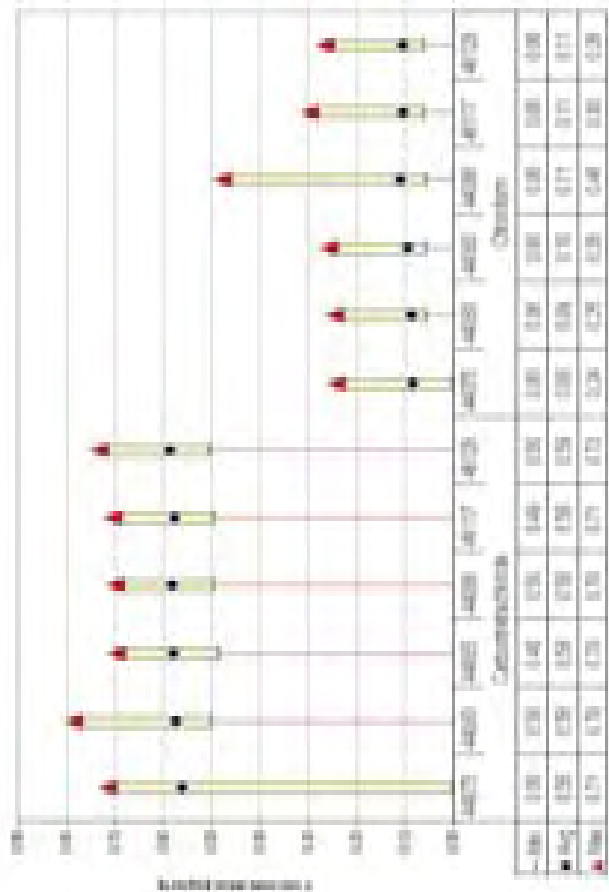
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A

FIGURE 7-3

B

Condition - SSC (No. Min. Avg. by Station for the Blount Monitoring Period)



Condition - SSC (No. Min. Avg. by Station for the Blount Monitoring Period)



C

FIGURE 7-3

D

Condition - SSC (No. Min. Avg. by Station for the Blount Monitoring Period)



Condition - SSC (No. Min. Avg. by Station for the Blount Monitoring Period)

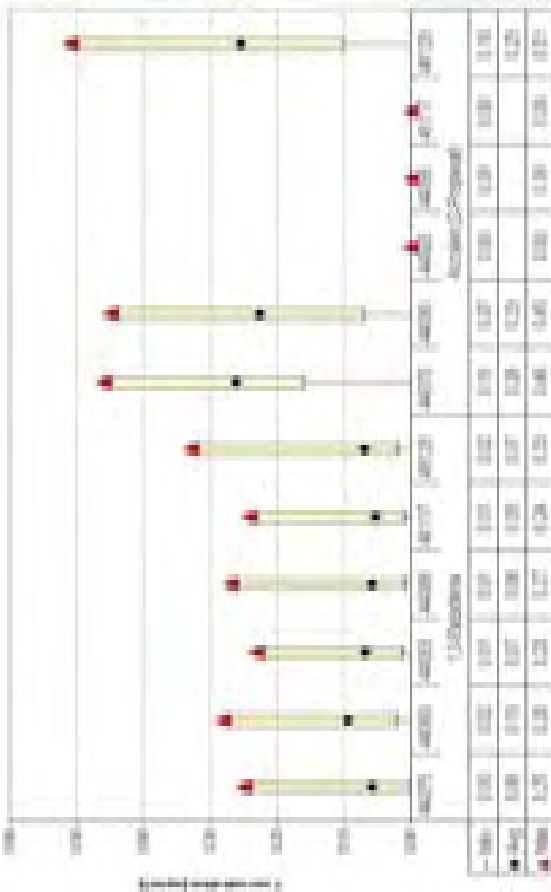


Figure 7.4

VOC Comparison (Clarkson STN vs Ontario STN)

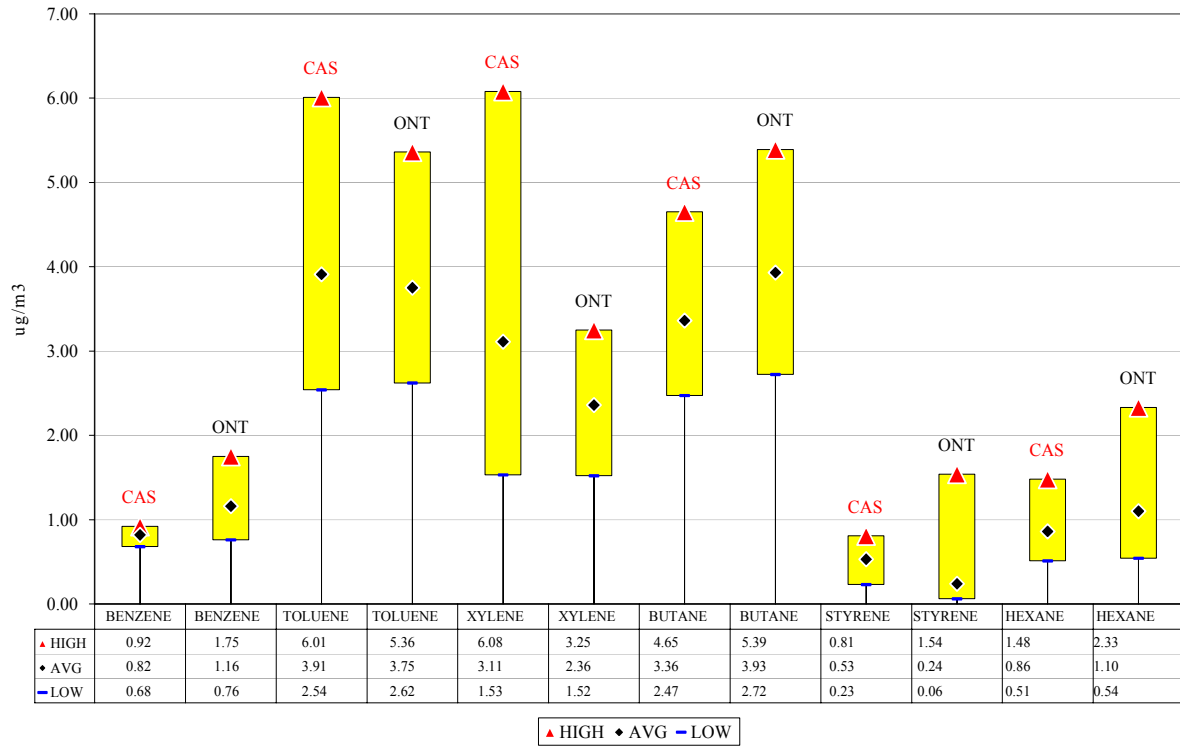


Figure 7.5

VOC Comparison (Clarkson STN vs Ontario STN)

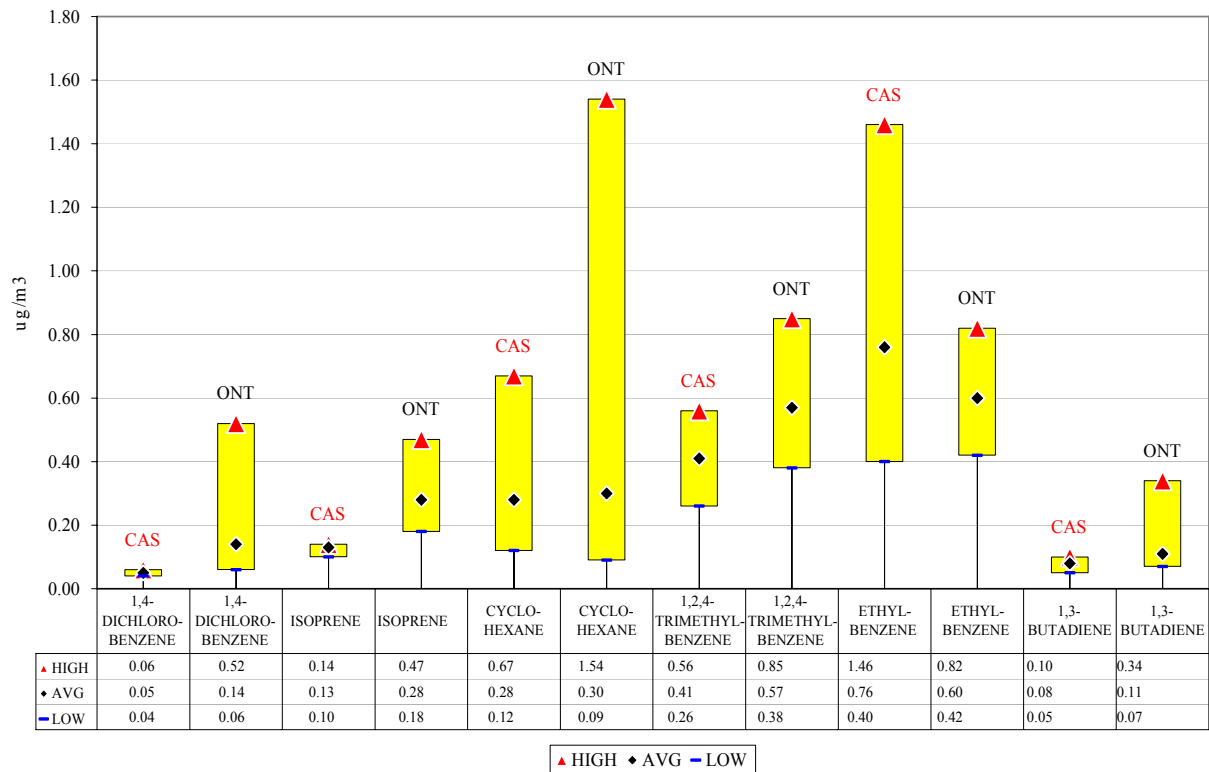


Figure 7.6

VOC Comparison (Clarkson STN vs Ontario STN)

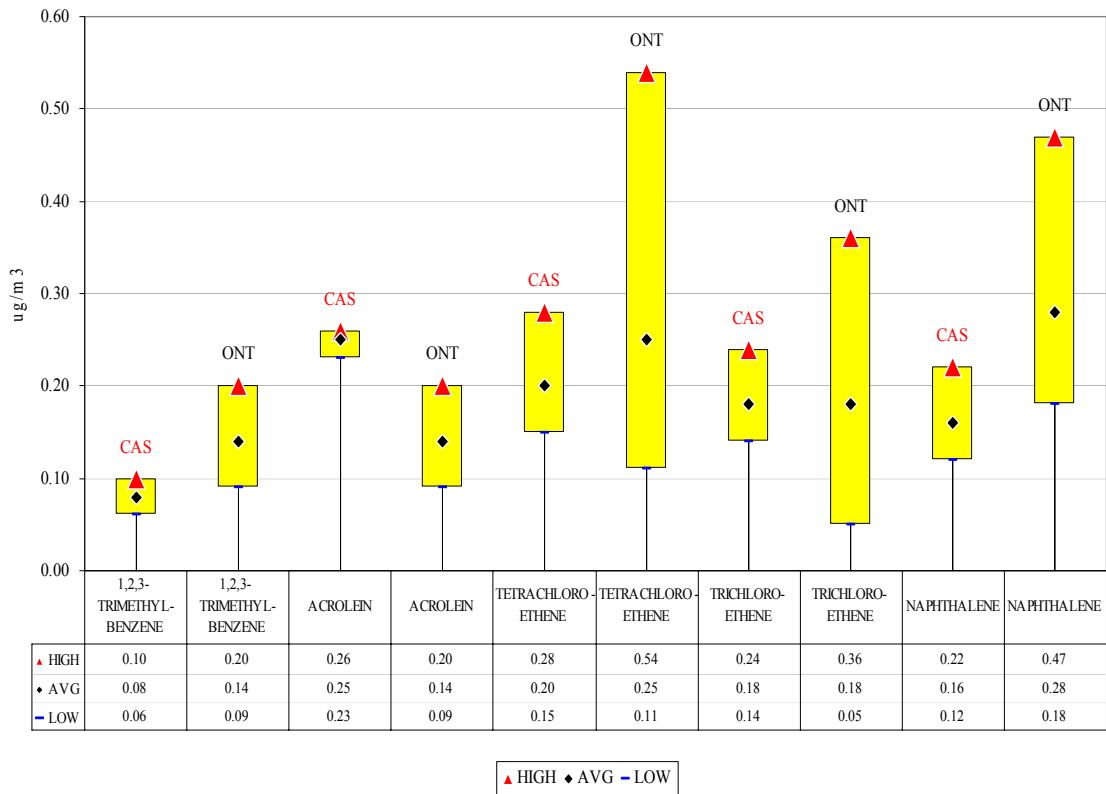
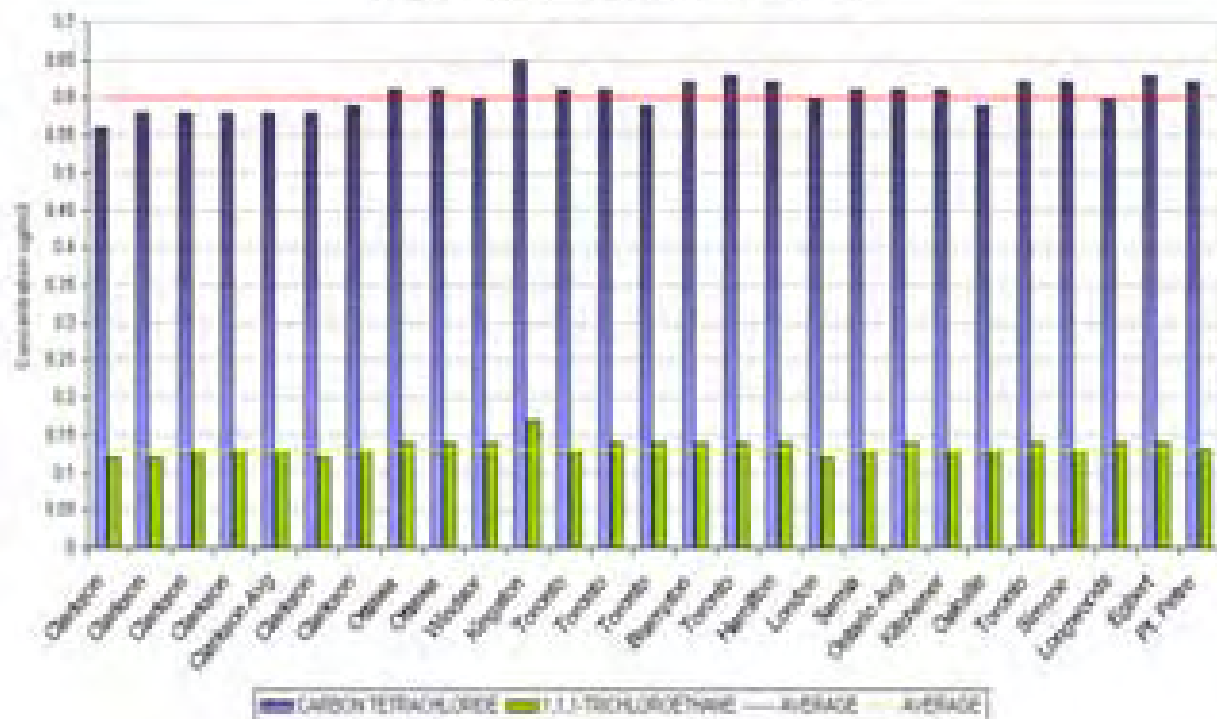


Figure 7.7

QA/QC DATA VERIFICATION  
CARBON TETRACHLORIDE & 1,1,1-TRICHLOROETHANE

## Section - Eight

# Conclusions & Next Steps

## Clarkson Airshed Study: Part II - The Ambient Air Monitoring Program

### 8.0 Conclusions

Monitoring data collected between June 2003 and March 2005 from the CAS study area indicates that, at times, especially during smog events, concentrations of respirable particulates ( $PM_{2.5}$ ) can be elevated and are considered to be contributing to a “taxed” area or an area which is compromised with respect to air quality.

In order to assist the Ministry in evaluating potential impacts of the measured  $PM_{2.5}$  concentrations, the proposed Canada Wide Standard of  $30 \mu g/m^3$ , based on 98<sup>th</sup> percentile values, has been used in this study as a *project benchmark concentration*.

During the 2004 portion of the CAS ambient air monitoring program and in fact, over the whole study period (2003-2005), annual average 98<sup>th</sup> percentile 24 hour  $PM_{2.5}$  concentrations at four of the six CAS stations exceeded the *project benchmark concentration*.

The average annual  $PM_{2.5}$  concentrations measured in the CAS study area in 2004 were among the highest found when compared to data obtained from the Ministry’s Air Quality Index Monitoring Stations. (Note: The AQI stations are situated so as to measure ‘general’ air quality whereas the CAS stations were focused on defining source input to the CAS study area.

Consequently our approach in comparing the two sets of values is only intended to give context to the CAS  $PM_{2.5}$  emissions, and caution is advised in interpreting this comparison.

The monitoring data collected in this study indicated that from the standpoint of annual average concentrations, industrial emissions may contribute as much as 25% of the  $PM_{2.5}$  concentrations in the CAS study area.

When looking at  $PM_{2.5}$  concentrations with respect to wind direction, elevated values exceeding the project benchmark concentration were found to occur when winds were originating from a south to south westerly direction (from over Lake Ontario). These high concentrations demonstrated the important contribution that transboundary air pollution makes to the area. This same wind direction also correlated well with wind directions recorded during smog events, which occurred primarily during the summer months.

On an on-going basis, vehicular traffic along major roadways contribute measurably to elevated respirable particulate matter (PM<sub>2.5</sub>), nitric oxide (NO), nitrogen dioxide (NO<sub>2</sub>), and concentrations found within the airshed study area.

Annual average concentrations of inhalable particulate matter (PM<sub>10</sub>) were fairly consistent from station to station; however, the interim 24 hour Ministry AAQC for PM<sub>10</sub> of 50 µg/m<sup>3</sup> was exceeded on several occasions. The PM<sub>10</sub> exceedances, like those of PM<sub>2.5</sub>, were closely associated with smog events and considered attributable to long range transport and industrial source emissions.

The 24 hour 120 µg/m<sup>3</sup> AAQC for total suspended particulate (TSP) was exceeded on four occasions, but these were considered minor. Three of the exceedances occurred during smog events.

When comparing the annual average 24 hour NO<sub>2</sub> concentrations for 2004 in the CAS study area to those from AQI stations in the GTA and Hamilton area, the CAS values were found to be among the highest for the stations compared (Note: The same caution as noted above for PM<sub>2.5</sub> applies for NO<sub>2</sub> when AQI data is compared with CAS station data. It is done only to provide some context to the measured CAS values).

The impact of vehicular emissions on NO concentrations was clearly demonstrated by the average hourly concentrations of NO found at the *QEW East* monitoring station. Levels at this station were 36% higher during the morning rush hour period than during the afternoon rush hour. During this morning period, winds were much lighter and dispersion was poor. It is important to note, however, that concentrations recorded at this station dropped rapidly with increasing distance from the roadway. At a distance of 300 meters, these levels were predicted to have decreased by 75-80%, which would more closely

mirror ambient background NO levels in the area.

The Ambient Air Monitoring Program measured 189 Volatile Organic Compounds (VOCs) in the samples taken from the Clarkson study area. With the exception of a few compounds, VOC concentrations were found to be similar to major industrial areas such as Toronto, Windsor, Sarnia and Hamilton. The VOCs measured appear to be largely a result of local industrial sources. (Note: Caution once again should be used in comparing CAS VOC data with the GTA/Hamilton data noted above that comes from the Environment Canada NAPS stations. The approach was taken to provide context to the CAS data).

For the VOC compounds for which the Ministry has an AAQC and an equivalent Reg 419 Schedule 3 standard, the measured concentrations were generally orders of magnitude lower than the criteria. An exception to this was one dichloromethane measurement, from the *Stn Industrial Centre* monitoring location. Concentrations of this VOC exceeded the criteria/standard on only a single occasion. No specific cause for this high level could be found.

Acrolein and acrylonitrile were also found to exceed new limits as identified in Schedule 3 of O.Reg. 419/05 and as such, require further monitoring and evaluation. It's likely that local industrial emissions contribute to these elevated levels; however, the precision and accuracy of these results requires further evaluation.

## 8.1 Next Steps

The Ministry will carry out additional monitoring for both acrolein and acrylonitrile and will continue with Part III of the CAS study to evaluate the contribution of specific sources to the air quality in the air shed. Following through on conclusions from the Ambient Air Monitoring Program as noted above, Part III will

extend our assessment of long range transport or transboundary impacts of key pollutants such as PM<sub>2.5</sub> on the CAS study area. Such an assessment will allow for a more specific identification of pollutant concentrations within the study area that are directly attributable to the transboundary issue.

Commensurate with completing Part III, the Ministry will proceed with Part IV of the CAS that will focus on achieving further abatement of the target pollutants from the 57 identified emitters that operate in the area.

It is expected that in 2007/2008, Part IV of the study will be initiated, which will include the establishment of an Advisory Committee consisting of representatives from the local public health department, municipalities, elected officials and Ministry representatives to liaise with industry and stakeholders with respect to the development and implementation of a permanent ambient air monitoring program for the community.



## *Section - Nine*

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## Clarkson Airshed Study: Part II - The Ambient Air Monitoring Program

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*Protecting our environment.*

